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INFLUENZAL CROUP*

JOSEPH C. REGAN, M.D., AND CATHERINE REGAN, M.D.

BROOKLYN

The epidemic of influenza which visited New York City during the months of September and October, 1918, afforded unusual opportunity to the clinician to study the disease in all its various phases. Unusual, and even rare symptoms, complications and types of the disease were seen, if not for the first time, certainly in greater numbers than since the pandemic of 1889.

We were fortunate enough to be able to observe and study a group of influenza patients who presented what was obviously an unusual clinical entity, namely, "influenzal croup." While we have been cognizant of the fact that, as Holt[1] declares, influenza may be one of the etiologic factors in acute catarrhal laryngitis, there has never come under our observation at the Kingston Avenue Hospital (in which the yearly admission of croup cases averages 300) more than an occasional patient suspected to be suffering from this condition. Even in such instances the true etiology was often obscure and the diagnosis commonly remained undecided. It is, of course, quite possible that in the past many of the cases of acute catarrhal laryngitis admitted as croup may have been of influenzal origin; but previous to the epidemic it has been very rare to be able to trace any definite association between the two maladies.

Toward the latter part of the epidemic it was observed that a number of croup cases admitted to the diphtheria wards of the hospital ran a very atypical course. The history of close exposure to typical cases of influenza, the clinical progress of the disease, the constant

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* From the Kingston Avenue Hospital for Contagious Diseases, Department of Health of New York City.

* The writers take this opportunity to thank Dr. Robert J. Wilson, director of the Bureau of Hospitals, Department of Health, for facilitating the studies on which this article is based. They also wish to thank Dr. Gustave Soderstrom for observations made on some of the cases included in the series. Also Mrs. B. Riehl of the laboratory staff for assistance rendered in the laboratory part of the work.

1. Holt, L. E.: The Diseases of Infancy and Childhood, New York, 1910, p. 492.

absence of membrane from the tonsils, the failure to respond to antitoxin, and the uncertain effects of intubation were all very suggestive of an etiology distinct from that of diphtheria. The bacteriologic and pathologic findings proved this to be the case. At first, however, the clinical resemblance to diphtheritic croup was so close that many of these cases of influenzal croup were admitted to our diphtheria wards under an incorrect diagnosis of laryngeal diphtheria.

Symptoms Previous to Admission.—For the purpose of study a series of twenty cases has been selected. Unfortunately, as the patients were mostly young children, a detailed history was often not obtainable; however, certain symptoms were sufficiently prominent for the parents to note.

As a general rule, it may be said that the disease started with the symptoms of influenza, and then after a period of from two to ten days the signs of croup appeared. Usually the onset of the primary malady occurred with a dryness, or, in some instances, soreness of the throat, and with a frequent, dry cough. In a few cases vomiting occurred at the start, but this rarely persisted for more than one day. Chills or a chilly sensation were frequently experienced. Pains in the lumbar region, in the limbs, and in the head were complained of by the older children and adults, and no doubt they were more common than the accompanying table would show, the younger children being unable to describe their symptoms. Oversecretion of the nose and eyes was observed in a few cases during the first few days of illness. In one patient the disease started with a generalized convulsion involving the whole body, the child then passing into a stuporous state and remaining so for several days afterwards. Rather profuse nosebleeds occurred in five cases of the series.

While one or more of these symptoms usually preceded the onset of croup, in a few instances the first symptom was a croupy cough, which became progressively worse, associated with symptoms of laryngeal stenosis (Case 3872).

Clinical Course.—The patients were admitted to the hospital in various stages of the disease, some presenting slight symptoms of laryngeal involvement and others showing definite evidences of obstruction to breathing.

The subsequent course depended on the extent and severity of the laryngeal involvement, and on the presence or absence of a complicating pneumonia. There were three types of cases: (1) a mild form; (2) a severe form with evidences of laryngeal stenosis but without definite pneumonic signs; (3) a severe form with evidences of laryngeal stenosis plus a pneumonia.

Our series is comprised of these two latter forms of the disease. There is nothing unusual about the mild form. It was merely the typical mild type of acute catarrhal laryngitis, plus the symptoms of influenza. Examples of this type were extremely common during the past epidemic both in children and adults. We shall not deal with it further than to say that symptoms of dyspnea are lacking.

In the severe cases there is at first the same hoarseness of voice and the croupy cough noted in the mild type. Then, after a lapse of from twenty-four to seventy-two hours, there begins to appear difficulty in respiration. The inspiration becomes audible, whistling, and is prolonged, and the expiration harsh, with a well marked interval between. (The respiratory rate does not increase notably unless a pneumonia is also present.) The patient is disturbed at intervals by a rather paroxysmal, racking, dry and unproductive cough. If any sputum is expectorated, and it is usually very scant, it is tenacious in character and composed of white glairy and stringly mucus. About this time there begins to appear a slight retraction of the soft parts of the chest with each inspiration, the suprasternal fossa and the epigastrium especially showing this change.

Examination of the throat shows an absence of exudate on the tonsils, but the pillars of the fauces, the soft palate and pharynx are of a deep red color, dry and shining. The tongue is usually very dry, feels hot to the touch, and is covered by a furred coating. Salivary secretion is very scant. There is no definite enlargement of the cervical glands and no nasal discharge. Examination of the chest shows diminished aeration, and a considerable number of sibilant or sonorous râles, which may be rhonchial in character. The percussion note is good throughout.

In from twelve to twenty-four or thirty-six hours the disease progresses to a period of marked obstruction. The retraction of the soft parts of the chest becomes more noticeable, the fossa above the sternum, the epigastrium, and the lower part of the chest, comprising the false ribs, being drawn inwards with each inspiration. Pallor appears around the mouth, the lips assume a cyanotic tinge, and the forehead is covered with perspiration. The face assumes an anxious expression. The pulse volume falls off during inspiration and eventually the pulse entirely disappears during this period of the respiratory excursion. At various intervals, which increase in frequency as the disease progresses, attacks of asphyxiation occur, the child becoming very restless, tossing around in bed, retraction is more pronounced, and the pulse disappears entirely with inspiration. The venous return flow being impeded, the veins of the neck stand out prominently with inspiration. Perspiration collects in large drops on the forehead and

a profuse secretion of sweat pours from the skin of the entire body. The cyanosis of the lips increases, the breathing becomes more audible and the child struggles to get its breath, using all the accessory muscles of respiration. After a few minutes the spasm subsides and the patient falls back in bed exhausted by the effort. Auscultation of the chest at this time shows a marked diminution of aeration throughout both lungs, with the presence of sibilant and sonorous râles. Occasionally the râles are rhonchial in character.

The symptoms after reaching this stage either continue to grow progressively worse until intubation is performed, or, as is more usual, under favorable circumstances, gradually subside, the signs of laryngeal stenosis becoming less, but remaining more or less marked for from three to five, six or seven days. The retraction disappears, the hard, dry cough is replaced by a more moist productive one, the respiration loses its inspiratory stridor, the pulse no longer varies with inspiration and the temperature falls. Examination of the chest at this time shows showers of moist râles more or less diffusely scattered through both lungs. The voice remains hoarse for some time (from ten to twenty-one days) after the other symptoms subside.

If a pneumonia complicates the clinical picture (and it is very common in our series — over 80 per cent.), the symptoms of laryngeal stenosis may overshadow the signs of pneumonia, as is commonly the case, especially in children, or else the course of the disease may be dominated by an extensive pneumonic process and the laryngeal symptoms appear only of secondary importance. Only two of our series presented this latter type of the disease (Cases 3466 and 3452).

Certain symptoms were prominent enough to require special remark. Many of the patients were irrational or delirious during the first few days in the hospital, and it was only with the greatest difficulty that they could be kept in bed. In several instances it was necessary to restrain the children to prevent their getting up. Sweating was rather common; one patient continued to perspire profusely for a period of ten days during the time in which the symptoms of laryngeal stenosis persisted (Case 3609). The croupy cough and hoarseness were often prolonged into convalescence, lasting for twenty-one days in one instance. Rather profuse nosebleeds occurred in two of the series (Cases 3871 and 2961).

The parched condition of the mucous membrane of the mouth and throat were especially noteworthy in many cases. The salivary secretion was very scant and the tongue dry and hot to the touch. This symptom was extremely marked in Case 3992, causing the patient to ask continually for something to moisten her mouth and throat.

No exudate was observed on the tonsils in any instance. The mucous membrane of the fauces, uvula, soft palate, pharynx and upper part of the larynx was, as a rule, considerably injected, and had a dry and glistening appearance, very much unlike the more moist appearance of the mucosa seen in diphtheria. The epiglottis was often swollen and in two or three instances rather edematous.

Secretion of the eyes and nose was lacking in all patients during the early congestive stage of the disease. Later, coincident with the beginning of the secretory stage, there was often a fairly profuse nasal and bronchial secretion.

The pulmonary signs during the congestive period in our cases were comprised largely of a diminution of vesicular breathing, which became gradually worse as the laryngeal stenosis progressed. At this time numerous sibilant and sonorous râles are often to be heard throughout the chest. Percussion may reveal dulness localized to one or more lobes, while auscultation of the same area gives little or no corroborative evidence of a pneumonic process. Yet the subsequent progress of the disease proves the presence of a pulmonary consolidation. Often areas of bronchopneumonia will be found scattered throughout the lungs, more noticeable after the symptoms of laryngeal stenosis somewhat subside. As soon as the secretory stage of the disease appears, numerous moist râles will be heard.

Etiology. 1. *Predisposing.*—(*a*) *Age:* Table 1 shows that with 3 exceptions the patients were all children. Evidently, this severe form of influenzal laryngitis is most common in children. (*b*) *Sex:* In the series, 12 of the patients were of the male sex and 8 were females; 3 of the latter being adults. The disease, therefore, appears to be more common among boys than girls. (*c*) *Nationality:* All the patients were born in this country with one exception, who was a native of Italy. Six of the patients were of Italian extraction, 1 was of German parentage, 1 of Scandinavian extraction, 2 of Russian parentage, and the parents of the remaining 10 were born in this country. (*d*) *Exposure to Cold:* In three instances it appeared that the disease had supervened after the early acute symptoms of influenza had subsided, following exposure to cold. (*e*) *Exposure to Diphtheria or Influenza:* In no instance was there a history of exposure to diphtheria. In 14 of the 20 cases there was a definite history of exposure to influenza. In 12 of the 14, to some one ill with influenza in the family, and in 2 instances other members of the family developed typical attacks of the disease a few days after the appearance of the symptoms of croup in our patients. Thus, in 14 instances there was a definite connection between influenza, on the one hand, and the disease which the patients developed, on the other. In some cases the connection was extremely

TABLE 1.—Classification of Cases; Also Showing History of Symptoms Previous to Admittance

Hosp. Case No.	Age, Years	Severity of Croup	No. of Days Ill on Admission	Chill	Character of Cough	Sore Throat	Predominant Symptom Pulmonary or Laryng.	Vomiting	Diarrhea	Secretion of Eyes and Nose	Nosebleed	Backache	Headache	Dyspnea, B. A.	Pain in Chest	Delirium	Convulsions, Coma	Complicated Pregnancy	Day of Disease Croup Developed	Antitoxin Units	Intubation, Size of Tube	Effect	Extubation, When	Duration of Severe Croup	Recovery or Death	Exposure to Influenza	Pneumonia, Lobar or Broncho
3898	6	Moderate	5	+	Croupy dry	+	Laryng.	..	..	..	..	..	+	+	..	..	..	..	3	15,000	No	.....	.....	4 days	R	+	Lobar
3609	6	Marked	4	+	Croupy dry	..	Laryng.	..	..	..	..	..	..	+	..	+	..	..	3	20,000	Yes	Became worse	Immediate	5 days	R	+	Bron.
2961	7	Marked	3	..	Croupy dry	..	Laryng.	+	..	..	+	..	..	+	..	..	..	..	2	None	No	.....	.....	2 days	R	+	Lobar
3633	7	Marked	4	..	Croupy	..	Laryng.	+	..	..	+	..	..	+	..	..	+	..	3	None	No	.....	.....	3 days	R	+	Lobar
3620	10	Marked	5	+	Croupy dry	+	Pulm. Laryng.	..	..	+	..	+	+	+	+	..	..	..	4	None	No	.....	.....	3 days	D	+	Bron.
3498	1	Moderate	7	..	Croupy	+	Laryng.	..	..	..	..	..	..	+	..	..	..	..	5	15,000	No	.....	.....	5 days	R	+	Bron.
3176	2½	Moderate	7	+	Parox. dry	+	Laryng.	..	+	+	..	..	..	+	..	..	..	..	4	15,000	No	.....	.....	.....	R	+	Bron.
3553	1½	Marked	12	..	Parox. dry	+	Laryng.	..	..	..	..	..	..	+	..	..	..	..	7	20,000	No	.....	.....	5 days	R	+	Bron.
3792	2½	Marked	7	..	Croupy dry	..	Laryng.	..	..	..	..	+	..	+	..	..	..	..	..	30,000	2 yrs. yes	Slight relief	Died in few days	.....	D	+	Bron.
3872	6	Marked	3	..	Croupy dry	..	Laryng.	..	..	..	..	..	..	+	..	..	..	..	..	20,000	4-5 yrs. yes	Became worse	Immediate	6 days	R	?	Lobar
3466	7	Moderate	2	..	Dry Parox.	+	Pulm.	..	..	..	..	..	..	+	..	+	..	..	1	15,000	No	.....	.....	2 days	R	+	Lobar
3452	9	Moderate	14	+	Prod. croupy	+	Laryng. Pulm.	+	..	+	..	..	+	+	..	+	..	..	12	20,000	No	.....	.....	3 days	R	?	Lobar
3732	7	Marked	3	..	Croupy	+	Laryng.	..	..	..	..	..	..	+	..	..	..	..	3	15,000	4-5 yes	Became worse at first, later relieved	4 days	3 days	R	+	None
2690	2	Moderate	3	+	Prod. croupy	+	Laryng.	..	..	+	..	..	..	+	..	..	..	..	2	26,000	No	.....	.....	3 days	R	+	None
3808	2½	Moderate	15	+	Croupy	..	Laryng.	..	..	..	..	..	..	+	..	..	..	..	13	20,000	No	.....	.....	.....	R	+	None
2972	4	Moderate	..	..	Croupy	..	Laryng.	..	..	..	..	..	..	+	..	..	..	..	..	None	No	.....	.....	.....	R	+	Bron.
3871	31	Marked	4	+	Croupy	+	Laryng.	..	..	..	+	+	+	+	..	..	..	+	2	20,000	No	.....	.....	4 days	R	?	Lobar
3764	2	Marked	2	..	Croupy	+	Laryng.	..	..	+	..	..	..	+	..	..	..	..	..	20,000	2 yrs. yes	Relief.	6 days	.....	D	+	Bron.
3992	24	Marked	5	+	Croupy	+	Laryng.	..	..	..	+	+	+	+	+	+	..	..	2	None	Yes adult	No relief worse	Immediate	7 days	D	?	Bron.
4065	25	Marked	7	+	Croupy Parox.	+	Laryng.	..	..	..	+	+	+	+	..	+	..	+	4	None	No	.....	.....	5 days	D	?	Bron.

striking; for example, the patient with croup would often be in the same bed with another member of the family, the latter presenting the classic symptoms of influenza.

2. *Exciting or Bacteriologic Cause.*—(*a*) *Nasopharynx Cultures:* Cultures from the nasopharynx were taken from 10 patients and gave

TABLE 2.—NASOPHARYNX CULTURES

Hospital Case No.	Pfeiffer's Bacillus	Pneumococci	Staphylococci	Streptococci Pneumo Group	Gram-negative Cocci	Saprophytes	Streptococci
3176	3	..	5				
3553	8	5	..	..	1		
3452	5	3	..	..	2		
2961	3	3	..	..	1	1	
3496	7	2	..	..	5	..	1
3609	3	1	..	..	4	..	1
3633	2	..	1	..	4	..	1
3896	4	..	..	10			
3732	3	3	2	..	..	..	1
3872	2	..	..	5	..	3	
Total	40	17	8	15	17	4	4

the findings shown in Table 2 (the bacterial ratio being indicated by the numerical figures). A glance at this table will show the predominance in number of colonies of Pfeiffer's bacillus; then, in order comes the pneumococcus, gram-negative cocci of the *Micrococcus catarrhalis* group, strep-pneumococci, and finally staphylococci in least numbers. (*b*) *Throat Cultures from Tonsils:* All throat cultures on Loeffler's blood serum medium were negative except Case 3872, which contained a few diphtheria bacilli. (Probably this patient was a carrier.) (*c*) *Sputum Examinations:* The sputum was examined in 5 cases and gave the findings shown in Table 3 (the bacterial ratio

TABLE 3.—BACTERIOLOGY OF SPUTUM

Hospital Case No.	Pfeiffer's Bacillus	Pneumococci	Staphylococci	Streptococci	Streptococci Pneumo Group	Gram-negative Cocci
3872	8	8	3	1	..	2
3871	5	2	..	..	20	
3872	3	0	5	0	5	2
3732	5	0	2	..	9	
3808	4	..	..	4	4	
3992	1	..	10			
3992	3	..	10			
Total	30	10	30	5	38	4

being indicated by the numerical figures). The examination of Table 3 shows the comparative frequency of the various organisms in the sputum. It will be noticed that diphtheria bacilli were lacking, and that strep-pneumococci and the Pfeiffer bacillus were most constantly found. (*d*) *Blood Cultures:* These were taken in Cases 4065 and 3992.

The latter patient's blood gave a growth of streptococci. (*e*) *Blood Counts:* The total white count varied considerably. In some instances a leukocytosis of from 13,000 to 33,000 was observed, while in a few others there occurred a leukopenia as low as 4,200 in one instance. The differential count did not vary greatly. (*f*) *Urine Examination:* In a few of the more severe cases the urine contained a cloud of albumin, and a moderate number of finely and coarsely granular casts. The specific gravity was that of febrile urines in general.

Postmortem Examinations.—Bacteriologic.—1. Cultures from the larynx were taken postmortem in five cases.

Case 3083. Pfeiffer 3, pneumococcus 2.
Case 3792. Pfeiffer 5, staphylococcus 2.
Case 3620. Pfeiffer 2, pneumococcus 2, staphylococcus 5.
Case 3620. Pfeiffer 4, pneumococcus 8, staphylococcus 5.
Micrococcus catarrhalis 1.
Case 4065. Staphylococcus 5.
Case 3992. Staphylococcus 12.

2. Cultures from trachea and bronchi:
Case 3993. Staphylococci 6, Pfeiffer 1.

3. Cultures from the lung:
Case 3792. Pfeiffer 8, staphylococci 2, gram-negative cocci 5.
Case 4065. Streptococci 5, pneumococcus 1.
Case 3620. Pfeiffer 2, pneumococci 12, streptococci 7.
Case 3083. Pfeiffer 3, strepto-pneumococcus 3, staphylococcus 4.

Macroscopic and Microscopic Pathology.—Four of the patients came to necropsy; the findings were as follows:

CASE 1.—*Macroscopic Pathology.*—V. W., aged 24; well nourished and developed; had a considerable amount of subcutaneous fat; post mortem lividity of dependent portions; rigor mortis rather marked.

Thorax: Pleura over left lower and upper lobe, especially along the fissure between the lobes, is clouded and nontransparent, and the surface shows many ecchymotic spots (hemorrhages under the visceral pleura). The pleura over the right lung shows the same changes but they are not so marked. Emphysema is rather marked along borders of both lungs, especially the upper right and upper left. The upper right presents two extensive areas of depressed, darkish-red lung tissue, which is firm to pressure and contains little or no air. Likewise, the left upper. The left lower contains no area of crepitation; it is firm to touch and of a dark red color. The right lower has a similar area but is crepitant along the borders.

On cross section of the lung a large amount of serous, frothy fluid exudes from the cut surface, both from lung structure and bronchi. The cut surface of the right lower is of deep reddish-purplish color, prune-juicelike, and exudes an enormous amount of serous fluid. A piece of this tissue sinks in water. The lung is like that of one with pulmonary consolidation and extensive edema.

The consolidation of the left lung is more marked; otherwise, the same as the right. The ecchymotic spots on the pleura extend from 1/12 to 1/16 inch into the lung substance.

Heart: The muscular wall of the right ventricle is rather pale and flabby. The cavity is somewhat dilated, and the muscular wall is thinned out. There is slight thickening of the tricuspid cusps. The left auricle and ventricle seem to be the proper size and the muscle is of good color and consistency.

The larynx is intensely congested and in places the mucous membrane is edematous, especially around the superior aperture. The epiglottis is definitely thickened and slightly edematous. The intense congestion of the mucosa is accompanied by the presence of very small white placques measuring about 1/16 inch in diameter scattered here and there over the surface of the mucous membrane. The intense congestion extends downward to the trachea and bronchi.

Cross section of tracheal and laryngeal mucosa showing typical pathologic changes.

The spleen is rather large and friable and the capsule is wrinkled. It is congested, reddish-purple color. The malpighian bodies stand out prominently, elevated above the surface and enlarged. There is a marked difference in the color of the elevated bodies and of the spleen substance, which is a deep blackish red as though from hemorrhage.

Kidneys: Capsule strips easily; markings are distinct, but cortex is rather pale.

Liver: This organ is rather pale, but the markings are quite distinct; veins are engorged.

Microscopic Pathology.—The lung is completely consolidated; exudate fills the alveoli, in some places red blood cells predominate. In other alveoli there are a fair number of polynuclear and epithelial cells; no fibrin.

The larynx shows changes similar to those recorded in Case 2. The liver shows some fatty degeneration. The kidneys show slight degenerative changes in the tubular epithelium.

Case 2.—M. Mc., aged 25.

Macroscopic Pathology.—The macroscopic pathology was similar to that in Case 1.

Microscopic Pathology.—Trachea and Larynx: The mucosa and the submucosa are considerably increased in thickness. The surface epithelium is intact and there is no evidence of fibrin formation. Just beneath the superficial layers of the mucous membrane there is an intense dilatation of capillaries. There is a marked exudate into the tissues surrounding the capillaries in both the mucosa and submucosa of polynuclear cells, lymphocytes and serum. The blood vessels of the submucosa are also intensely dilated, being filled with contents fluid rather than cellular. The infiltration of polynuclears and lymphocytes extends to the middle layers of the submucosa. It is more intense in some areas than in others. The glandular acini are distended with mucus. The typical changes noted in a diphtheritic involvement—fibrin formation and necrosis of the superficial layers—are lacking (see photomicrograph).

Lungs: Consolidation; alveoli filled with exudate, composed of serum, many polynuclear and epithelial cells. The alveolar walls are thinned from the pressure of the exudate. The liver shows fatty infiltration, cloudy swelling, and slight degenerative changes in the cells. The kidneys are normal.

CASE 3.—K. S., aged 2½ years.

Macroscopic Pathology.—This is very similar to that of the preceding cases, except that the pneumonic process is typically bronchial in type. The larynx shows the same intense congestion, but there is slightly less edema, and there were no small minute white placques on the mucosa.

Microscopic Pathology.—The lungs show complete consolidation; the cells in some areas are degenerated; some fibrin; polynuclear cells predominate. There are a few epithelial cells. In some areas red blood cells are present.

Liver: There is slight lymphocytic infiltration of the portal canals.

Spleen: Normal.

CASE 4.—G. P., aged 10 years. Macroscopic pathology of larynx as in Case 3.

No microscopic pathology.

Diagnosis.—Influenzal croup is to be differentiated from retropharyngeal abscess, foreign body in the larynx, other forms of acute catarrhal laryngitis, and finally from diphtheritic or membranous croup. A thorough history and complete physical examination should be sufficient easily to differentiate this influenzal type of croup from all other conditions except laryngeal diphtheria. In distinguishing it from the latter disease due importance must be given to the epidemic prevalence of diphtheria or influenza, to the history of exposure, to the symptoms of onset, to the appearance of the throat and the presence or absence of membrane on the tonsils, and finally to the bacteriologic findings on culturing the tonsils, the nasopharynx and the sputum. A direct laryngoscopic examination of the larynx is advisable to insure the diagnosis, providing the child is not too desperately ill and is not too much excited by the procedure.

Prognosis.—Death occurred in five of our series of twenty cases of influenza croup. All five patients had an extensive bronchopneumonia. Two of the five were adults (Cases 3992 and 4065), and both of these patients had a streptococcus and staphylococcus laryngitis and tra-

cheitis, with an extensive, massive bronchopneumonia. Three of the patients were females, one of them being pregnant. Despite the severity of the symptoms of laryngeal stenosis and the desperately ill condition of many of the other patients' recovery very uniformly occurred. This was the more interesting because, with but three exceptions, they all had pneumonia.

Treatment.—A definite diagnosis from laryngeal diphtheria is so difficult to make in most cases without bacteriologic findings, and a direct laryngoscopic examination presents so many difficulties under conditions where the children are irrational, difficult to control and intensely dyspneic, that it seemed advisable to administer diphtheria antitoxin to all uncertain cases on admission. Thus, 15 patients of the series received intramuscular injections of antitoxin varying in amount from 15,000 to 30,000 units. This is probably the best plan to follow, although the antitoxin seems to have little or no action on the local process.

The treatment which proved exceedingly effective in our hands was the use of steam inhalations. Our new isolation building comprising a lower floor of twenty isolation units of one small room each, was very useful for this purpose, as ventilation could be carefully controlled by means of a transom above the door and the atmosphere of the room was easily saturated with steam vapor. The use of steam under such favorable conditions which allow of the concentration of vapor and yet permit a plentiful supply of oxygen obviates the necessity of employing a croup tent. The latter always has the objectionable feature that it prevents the patients from receiving a continuous renewal of fresh air by interfering with free circulation, the result being that part of the expired air is continuously being inspired over and over again. For this reason it cannot be employed continuously. Moreover, it is often rather prostrating for the patient if he is kept in the tent too long. Obviously, these objections cannot be applied to the method described.

Our results from the use of steam in this way have been exceedingly satisfactory. Many of the patients successfully treated without intubation would almost assuredly have required a tube had they been admitted to an open ward. The relief afforded by the steam in these cases was even more marked than attends its use in laryngeal diphtheria. Compound tincture of benzoin was always used in conjunction with the steam.

In addition to inhalation, flaxseed poultices were applied to the neck, being changed frequently so as to supply a continuous, even, warm temperature. These applications also proved very helpful.

In the line of drugs, morphin sulphate and atropin sulphate in

doses proportionate to the age of the child and given at four-hour intervals were most effective. Thus, for a child of 4 years, morphin sulphate, $\frac{1}{24}$ grain, and atrophin sulphate, $\frac{1}{360}$ grain, were given for a few days. The atropin was valuable in assisting to control the spasms which occurred from time to time in severe cases, and the morphin by its sedative and hypnotic action kept the patient quiet and all unnecessary strain off the heart. These drugs were supplemented by small doses of spiritus frumenti and in bad cases by one of the digitalis group. In one case epinephrin chlorid (1 to 1,000 solution) was used with beneficial effect.

In only six instances was it necessary to resort to intubation. Five of the patients were children and one was an adult (Case 3992). The immediate effect of the introduction of the tube in four of the six cases was to make the patient worse. Owing to the edema which existed in most severe cases around the superior aperture of the larynx, involving the epiglottis, and often extending downward to the lining mucosa of the larynx and trachea, it was common to find difficulty in inserting a tube proportionate to the age of the child. The bad effect of intubation in the few cases tubed was shown by the increasing cyanosis, the intense air hunger, the thready pulse and the extreme restlessness of the patient; symptoms which came on immediately after the operation. By reason of these grave signs of asphyxiation, the tube was left in situ as long as it seemed advisible to wait, usually one or two minutes to see if any relief was afforded; then it was removed. The detrimental effect of the operation seemed to be due to the pressure of the intubation tube in the larynx increasing the congestion existing in the mucous membrane below, further adding to the mechanical obstruction. Even in these four patients, however, the intubation seemed to have one beneficial effect, in that following the removal of the tube the patient would often cough considerably, expectorating rather profusely, with the resultant temporary improvement in breathing.

Two of the six patients were definitely relieved by the intubation, the tube remaining in situ for six days in one case and for four days in another.

It must be said, however, that if possible, intubation is to be avoided in influenzal croup, for several reasons. In the first place pneumonia is very common in this disease, and as we know, tube cases do rather poorly if complicated by a pulmonary consolidation. Then again, the rule is that the introduction of the tube is followed by an increase in the symptoms of dyspnea, necessitating its immediate removal. Finally, a large proportion of the patients recover if given suitable treatment, without operative interference.

ADDITIONAL CASE REPORTS ILLUSTRATING INFLUENZAL CROUP

CASE 5 (No. 3732).—Boy, aged 7 years, admitted to Kingston Avenue Hospital Nov. 2; discharged Nov. 20, 1918.

History.—The patient was taken ill three days before admission, with a croupy cough, very hard and unproductive in character. On the second day of illness he began to breathe with difficulty, this became worse until he was quite dyspneic. The patient's brother, a boy of 10 years, was taken sick one week previously with the usual symptoms of influenza.

Physical Examination.—On entrance the patient was seriously ill, with extreme dyspnea, retraction of the chest, cyanosis and rather poor pulse.

Throat: There was redness of the faucial mucosa; pillars of fauces, tonsils and pharynx were markedly dry. The tonsils were somewhat enlarged and reddened, but there was no exudate visible. The tongue was not coated but was a deep red, cyanotic color, and was hot and dry to touch. The face was of a dusky, cyanotic tinge, with a rather marked circumoral pallor.

There was marked retraction of the lower part of the chest and epigastrium with each inspiratory effort, and at the same time the suprasternal fossae were depressed and the accessory muscles brought into play. The pulse disappeared with inspiration and the veins of the neck stand out prominently. The heart sounds at the apex were of fairly good muscular quality, but were obscured by a blowing, systolic murmur. The heart action was tumultuous. No dilation of the right heart could be made out by percussion, but with each inspiration the heart sounds almost ceased, and the pulse disappeared. The lungs showed no change on percussion either anteriorly or posteriorly, but on auscultation of the chest the areation was markedly diminished, and the sounds were more tubular, and there were some sibilant râles The abdomen was negative. Temperature, 101 F.; pulse, 140; respiration, 26.

Treatment.—On admission, owing to the patient's condition, intubation was decided on and was performed with a 4 or 5-year tube. On introducing the fingers the epiglottis felt edematous and swollen, the swelling involving also the structures at the superior aperature of the larynx. Difficulty was experienced in introducing the tube into the opening of the larynx, and after that, of inserting it further, marked obstruction was overcome with a little pressure and the tube glided into place. The child became intensely cyanotic during this time and remained so for several minutes after the operation. Then retraction became less and breathing improved.

Subsequent Course.—The patient's condition was very satisfactory after the intubation, and dyspnea did not again return. He was extubated four days later and went without the tube. Convalescence continuing uninterrupted, he was discharged November 2, completely recovered.

CASE 6 (No. 3872).—A boy, 6 years old, was admitted to Kingston Avenue Hospital, November 12 and discharged November 30.

History.—The child was taken ill November 10, with a hard, barking, croupy cough. The following day he became worse and began to have slight difficulty in breathing. On the day of admission the dyspnea became more intense.

Physical Examination.—On entrance the patient was extremely ill, almost moribund. Intense dyspnea and cyanosis of the skin and mucous membranes were present. Suprasternal, infrathoracic, and epigastric retraction were marked. There were excoriation of the anterior nares and serous discharge from one nostril; no glandular swelling of the neck. Chest: poor areation of both lungs; the inspiration was markedly diminished on both sides, anteriorly and posteriorly, and there were numerous sibilant and sonorous râles, rhonchial over right base. The percussion note was hyperresonant over right lower, but just slightly impaired over the middle lobe. The heart sounds were very irregular and weak at the apex. The pulse was of poor volume and was irregular. Temperature, 103 F.; pulse, 160; respirations, 50.

Treatment.—On admission, diphtheria antitoxin (20,000 units) was administered and for a few hours palliative measures, flaxseed poultices and steam inhalations were used; also good sized doses of atropin and morphin. Before long, however, the patient's condition became so serious that intubation was decided on. A 4 to 5-year tube was introduced, but only with some difficulty. It gave no relief and the child became intensely cyanotic and restless. The tube was allowed to remain in situ for about one and a half minutes and then removed, as asphyxiation seemed imminent. Some mucus was expelled following the removal of the tube. Treatment by steam inhalations and poultices was then resumed with satisfactory results.

Subsequent Course.—For two days the symptoms of croup remained very intense, frequent spasms occurring, during which the patient would reach the verge of asphyxiation. After this the laryngeal stenosis gradually subsided, leaving only a hoarse, croupy cough.

On examination, November 19, the patient was greatly improved, breathing, however, with a slightly audible inspiration but no retraction. The pulse was of good volume and regular; heart sounds normal. Posteriorly over the left lower chest there was slight dulness, and in the same area a diminution of breathing and numerous moist râles were heard with inspiration and expiration. The patient improved progressively and was discharged November 30, completely recovered.

CASE 7.—Illustrating a rather mild type of influenza, croup and pneumonia, which subsided promptly after the use of antipneumococcus serum (Type I).

History.—D. D., aged 2½ years, taken ill February 1, with symptoms of a "cold," sneezing, coughing, and nasal discharge. The cough later in day became croupy. The patient became progressively worse and on the following day one of the writers was called to see her. At this time the temperature-pulse-respiration ratio was 102; 148; 34. There was distinct dyspnea and stridor with each inspiration, breathing being very audible, although the laryngeal obstruction was not yet advanced enough to produce retraction or to influence the pulse.

Examination.—Examination of the throat showed a rather intense congestion of the mucosa of the soft palate, pillars, and pharynx; the throat having, however, a dry, glistening appearance. No exudate was visible on the tonsils. On percussion of the right chest posteriorly, there was beginning dulness over the lower lobe, and on auscultation over the same area there were some fine crepitant râles at the end of inspiration. Vesicular breathing was diminished and in places the breath sounds were rather bronchial. The cough was frequent, dry and croupy. A throat culture and a specimen of sputum were taken. The usual routine treatment by poultices, steam inhalation, etc., was started, and 15,000 units of diphtheria antitoxin were administered.

The next day, February 3, the patient was again seen. The symptoms remained about the same, the stenosis increasing slightly. As the cultures taken the previous day showed Type I pneumococcus, and as the pulmonary signs of lobar consolidation were more definite, 30 c.c. of antipneumococcus serum were injected into the muscles of the buttocks. February 4, the child was seen again. There was remarkable improvement; the symptoms of laryngeal stenosis had almost completely disappeared, the cough was soft and productive, there was beginning return of the normal pulmonary resonance in the right middle and lower lobes, and the breathing was more vesicular in character. Temperature, 99; pulse, 108; respirations, 24. After a few days the child was completely well.

CASE 8.—Illustrating a case of influenza followed by a relapse with the symptoms of croup and rapidly fatal termination.

History.—S. M., aged 4 years, was admitted to the hospital March 11, at 6:30 p. m., with a history that the patient first became sick March 7, with symptoms of a "cold." She sneezed several times, coughed considerably, and

there was a nasal discharge. Soreness of the throat was noted and the child vomited once. The symptoms seemed to subside and she was allowed out to play on the ninth. The patient remained apparently well until the evening of the tenth, when, after coming in from the "movies," at about 9 p. m., the parents noted that she was becoming very croupy and her breathing was becoming somewhat difficult. The breathing became progressively worse and the child was admitted to the hospital the following day in an extremely poor condition.

Examination.—On admission (less than twenty-four hours after the onset of croup) the patient was extremely dyspneic, there was fairly marked retraction of the lower ribs and epigastrium; also suprasternal retraction with each inspiration, the pulse disappearing during the same period. There was cyanosis of the mucous membranes, the face was a deadly white color, and the heart sounds at the apex and at the aortic and pulmonic valves were of poor quality. Numerous moist râles were to be heard throughout both lungs, but vesicular breathing was greatly diminished. The child was only semiconscious and was sinking rapidly, the pupils being constricted and reacting little to light. The temperature-pulse-respiration ratio was 103; 150; 42. Despite energetic treatment the patient became rapidly worse, the pulse disappearing entirely with inspiration and remaining just palpable between. Intubation was tried, a 3-year tube being used; the result was only to aggravate the obstruction; hence the tube was immediately removed. The patient died two hours after admission. The examination of the larynx postmortem showed the usual changes; cultures on blood agar plates showed pneumococci and gram-negative bacilli, probably Pfeiffer's bacillus. Cultures on Loeffler's medium gave a growth of pneumococci.

SUMMARY

During the past epidemic of influenza a number of cases of "influenzal croup" were encountered. The history of close exposure to typical cases of influenza, the clinical course of the disease, the constant absence of membrane from the tonsils, the failure to respond to antitoxin, and the uncertain effects of intubation were all suggestive of an etiology distinct from that of diphtheria. Bacteriologic and pathologic findings proved this to be the case. At first, however, the clinical resemblance to membranous croup was so close that many of the patients were admitted to our diphtheria wards under an incorrect diagnosis of laryngeal diphtheria.

As a rule, the disease begins with the symptoms of influenza, and then, after a period of from two to ten days the signs of croup appear. The subsequent course of the malady is similar to that of diphtheritic croup, and depends on the severity of the laryngeal involvement and on the presence or absence of a complicating pneumonia. It was common for the symptoms of laryngeal obstruction to progress to a point of impending asphyxia, during periods of spasm, and at such times there was marked retraction of the suprasternal fossae, and of the epigastrium, disappearance of the radial pulse during inspiration, noisy breathing, cyanosis of the skin and mucous membrane, profuse sweating and extreme restlessness. In a small percentage of cases

these attacks of asphyxiation increase in frequency and severity to such a degree that operative interference is required or death results. More commonly, however, under favorable conditions of treatment the frequency and severity of the spasms diminishes, and after from three to five days they disappear altogether. If a pneumonic complication exists, as is commonly the case, the symptoms of laryngeal stenosis usually dominate the clinical picture, the pneumonia occupying a place of secondary importance. Under such circumstances auscultation of the chest will often fail to reveal the presence of a pulmonary consolidation, owing to diminished areation; but percussion may bring out areas of dulness.

Certain symptoms of influenzal croup differ from those found in laryngeal diphtheria. Thus, the tonsils and larynx are free of membrane; the mucous membrane of the throat having a deep red, dry, glistening appearance distinct from the more moist appearance common in diphtheria. The mucosa of the mouth is parched and in the early stage of the disease the tongue is dry and feels hot to touch. Auscultation of the chest reveals the presence of a considerable number of sibilant and sonorous râles.

In two instances the disease was complicated by pregnancy. In one case both the mother and the child died, and in the other, the mother recovered and there was no obvious effect on the child.

Influenzal croup was most frequent in children between the ages of 3 and 10, boys being more often affected than girls. In no instance was there a history of exposure to diphtheria, while in fourteen of the twenty cases of our series there was a definite history of exposure to influenza; in most all, to some one ill with the disease in the immediate family. Often the connection between the two conditions was extremely striking.

Death occurred in five of the series. The mortality was rather low, inasmuch as many of the patients presented symptoms of extreme laryngeal stenosis, and all but three had pneumonia.

The causative agent of this particular form of croup is not the diphtheria bacillus. Cultures taken from the nasopharynx, the tonsils and the sputum during life, and from the larynx, trachea and lungs after death, all uniformly failed to show the Klebs-Loeffler bacillus. The bacterial flora found were very similar to that noted in general among influenza cases. Thus in the nasopharynx cultures there was a predominance of the Pfeiffer bacillus, pneumococcus, and *Micrococcus catarrhalis*. In the cultures from the sputum strep-pneumococci and Pfeiffer bacilli were most common, with pneumococci and staphylococci in less numbers.

In cultures taken postmortem from the larynx and trachea, staphylococci were most constant, Pfeiffer's bacilli and pneumococci being next in order of frequency. In cultures taken from the lung, Pfeiffer bacilli were predominant, with streptococci and staphylococci in somewhat less numbers.

The blood picture varied. Leukopenia occurred, but was very inconstant. A moderate leukocytosis was most constant, as the frequency of pneumonia would lead one to expect. Blood cultures in one instance showed streptococci.

Four patients came to necropsy. In two of the four the gross pathology was very similar. In each of these two cases there was an extensive massive bronchopneumonia in the lower lobes of both lungs with ecchymotic spots under the pleura, together with a severe grade of edema of the unconsolidated tissues. The larynx was intensely congested, the mucous membrane of the epiglottis swollen and edematous; likewise, the mucosa around the true and false cords. The congestion and, also to a lesser extent, the edema extended downwards to the trachea and bronchi. Scattered here and there over the surface of the mucous membrane were a number of minute whitish plaques measuring about one-twelfth of an inch in diameter, and easily removed from the mucosa. The spleen appeared enlarged and congested in both cases.

In the third case there was the same extensive bronchopneumonia, with severe congestion and some edema of the larynx, but without any exudate on the membrane. In a fourth case only the larynx was examined; in this instance the larynx appeared the same as in the last mentioned necropsy.

Microscopic sections of the larynx and trachea showed definite pathologic changes. The surface epithelium of the mucosa was intact, and there was no evidence of fibrin formation, showing its dissimilarity to diphtheritic laryngitis. But the blood vessels of the mucosa and submucosa were markedly dilated, and there was an extensive exudation of polynuclear cells, lymphocytes and serum into the surrounding tissues. The thickness of the mucosa and submucosa was greatly increased by this infiltration of its tissues and the dilatation of its blood vessels.

In the treatment of the malady it was found usually best to administer diphtheria antitoxin, owing to the difficulty of making a definite differential diagnosis from laryngeal diphtheria. Direct laryngoscopic examination presents many difficulties in patients who are irrational, difficult to control, and intensely dyspneic. Then again, cultures require time for examination. The treatment which proved exceedingly effective was the use of steam inhalations, carried out in a small room

in which the saturation of the atmosphere with vapor could be carefully controlled. The results were very satisfactory, and there is little doubt that a number of intubations were thus avoided. In addition to steam inhalations, flaxseed poultices were applied to the neck; morphin sulphate and atropin sulphate were given in doses proportionate to the age, to control the spasms and the restlessness. Intubation was required in six patients, one being an adult. The immediate effect of the introduction of the tube in most instances was to make the patient worse, and extubation had to be immediately performed in three cases. The harmful effect seemed to be due to the fact that the pressure of the tube increased the congestion existing in the mucous membrane below, further adding to the mechanical obstruction.

Antipneumococcus serum was used in one case with very beneficial effects. It well deserves a trial, especially as the causative agent is often associated with the pneumococcus; more commonly is this the case in children. In adults the infection is often of a somewhat different type, the streptococcus and staphylococcus often predominating; in the former instance a polyvalent streptococcic serum would be well worthy of trial. In instances in which the predominant infection is streptopneumococcus, a combined polyvalent streptococci and pneumococci serum should be used. Diphtheria antitoxin seems to have no effect on the local process.

We look forward with anticipation to the publication of the detailed work which Dr. Henry L. Lynah of New York City, our attending laryngologist, has been doing on this subject of influenzal croup.

SOME GRAPHS AND TABLES ILLUSTRATING THE GROWTH OF THE HUMAN STOMACH *

RICHARD E. SCAMMON, PH.D.
INSTITUTE OF ANATOMY, UNIVERSITY OF MINNESOTA
MINNEAPOLIS

The importance of an accurate knowledge of the anatomy of the stomach in early life has long been appreciated as is evidenced by the numerous publications on the subject. In recent years, particularly, our concepts of the form and position of the infant's stomach have been entirely recast by the results of the series of roentgenographic studies initiated by Levin and Barret[1] and continued by a number of investigators in this country and elsewhere. A number of studies have also given us at least a working knowledge of the finer structure of the organ in childhood. Yet, regarding the actual growth of the stomach, there is probably less known than of any of the other larger organs of the body. Although there are a number of scattered observations on the weight of the stomach at various periods of life, apparently no attempt has ever been made to bring these together or to follow out the general scheme of the mass increase of the organ. The same remark holds true for the increase in the area of the gastric mucosa. Regarding the growth of gastric capacity, there is, of course, a very large quantity of data, and this has been summarized from time to time in the studies of Pfaundler,[2] Borie,[3] Marfan,[4] Figueira,[5] and others. It is, however, over fifteen years since a new synthesis of this material has been attempted, and a very large amount of new data on the subject has accumulated since that time. This condition seems to warrant the presentation of a series of statistics on stomach growth together with a graphic analysis of some of the more important material.

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2. Pfaundler, M.: Ueber Magencapacität und Gastrectasie im Kindesalter, Biblioth. med. Suppl. 4, Part 5, 1898.

3. Borie, P. R.: L'estomac du nourrisson, Anatomie et Physiologie, Thèse Paris, 1899.

4. Marfan, A. B.: Traite de l'allaiment et l'alimentation des enfants du premier age, Paris, 1903, Ed. 2, p. 293.

5. Figueira, F.: Eléments de séméiologie infantile, Paris, 1903, p. 206 et seq.

1. GROWTH OF THE STOMACH IN WEIGHT

Somewhat over 1,400 determinations of the net weight of the stomach are available for study. Of these, 839 are weighings of adult stomachs (of individuals from 20 to 60 years of age), 476 are of individuals of the first two decades of postnatal life and the remainder are of new-born infants and fetuses. Unfortunately, only a portion of this material is available in the form of individual cases. The data on the weight of the stomach in the latter part of childhood and in adolescence come almost entirely from the tables of Boyd,[6] whose findings were published only in summary, and whose original records were completely destroyed many years ago. This makes it necessary to group the cases of this period in larger divisions of time than would otherwise be used. However, Boyd's material for early childhood is arranged in small time units which allow a detailed study of this period. The data on stomach weight are shown in tabular form in Table 1, and Figures 1 to 5, inclusive, are graphs based on them.

TABLE 1.—THE GROWTH OF THE STOMACH IN WEIGHT IN FETAL AND POSTNATAL LIFE (1,436 CASES) *

Age	Number of Cases	Average Net Weight, Gm.	Average Relative Weight	Average Weight in Terms of Weight of Stomach of New-Born	Average Weight in Terms of Weight of Adult Stomach
3d fetal month	2	0.125	0.250	0.019	0.0008
4th fetal month	2	0.325	0.330	0.050	0.002
5th fetal month	5	0.512	0.224	0.078	0.003
6th fetal month	6	0.99	0.303	0.152	0.006
7th fetal month	11	1.89	0.275	0.290	0.012
8th fetal month	13	2.77	0.301	0.426	0.017
9th fetal month	7	3.90	0.227	0.600	0.025
10th fetal month	8	4.85	0.190	0.746	0.031
Newborn	167	6.49	0.225	1.00	0.042
0 to 3 months	34	10.9	0.371	0.167	0.070
3 to 6 months	39	14.1	0.417	2.17	0.091
6 to 12 months	71	18.3	0.352	2.81	0.118
1 to 2 years	62	27.1	0.434	4.17	0.175
2 to 4 years	55	37.9	0.439	5.83	0.245
4 to 7 years	48	51.8	0.438	7.97	0.335
7 to 14 years	35	80.8	0.487	13.81	0.581
14 to 20 years	32	128.9	0.430	19.98	0.834
20 to 60 years	839	154.5	0.309	23.77	1.000

* Based on data collected by Arnovljevic, S.: Das Alter, die Grössen und Gewichtsbestimmung der Foetalorgane, Dissert. München, 1884; Boyd, R.: See Footnote 6; Brandt, E.: Das Alter, die Grössen und Gewichtsbestimmung der Foetalorgane, Dissert. München, 1886; Clendinning, J.: Facts and Inferences Relative to the Condition of the Vital Organs and Viscera in General as to Their Nutrition in Certain Chronic Diseases, Medico-Chir. Tr. **21**:32, 1836, and the author.

The first part of Table 1 and the graphs shown in Figures 1 and 2 illustrate the growth of the stomach in fetal life and its weight at birth. The youngest stomachs weighed were of two fetuses of the latter part of the third fetal month. At this time the weight of the organ is 0.125 gm. This weight is almost tripled in the fourth fetal

6. Boyd, R.: Tables of the Weights of the Human Body and Internal Organs in the Sane and Insane at Various Ages, Arranged from 2,640 Post-mortem Examinations, Phil. Tr. Roy. Soc., London **151**: 1861.

month and is more than quadrupled in the fifth fetal month. In the sixth month the average weight of the organ is approximately 1 gm., or about eight times that in the third. In the seventh month the average weight has risen to nearly 2 gm., and in the eighth to 2.77 gm. The average weight of the organ in the ninth fetal month is approximately 3.9 gm., in the tenth month 4.8 gm., and in the full-term new-

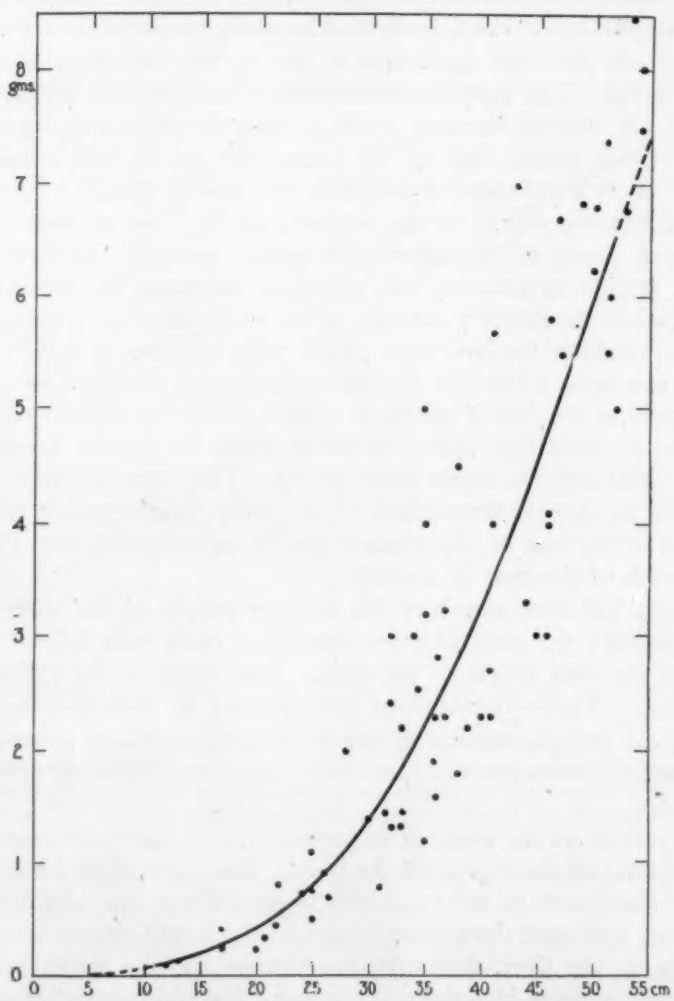

Fig. 1.—A field graph and curve illustrating the growth of the stomach in net weight during fetal life. Abscissa: total body length in centimeters; ordinate: net weight of stomach in grams. The distribution of the individual cases is shown by dots. The curve of average weight is based on the figures presented in Table 1. The position of the determining points on this curve have been weighted for the distribution of cases as to body length and the curve has been slightly smoothed by inspection.

born approximately 6.5 gm. The fetal growth of the organ is evidently a very rapid one. In the early part of prenatal life the organ approximately doubles its weight with each fetal month. Thereafter the rate of growth drops to about 40 per cent. per month for the last third of prenatal life.

Looking at the process of growth of the stomach in fetal life as a whole, we find that the organ has acquired about one-fiftieth of its natal weight in the third fetal month, nearly one-sixth in the sixth, between one-third and one-fourth in the seventh, and over two-fifths in the eighth. The exact determinations of this ratio of the last two months are difficult because of the uncertainty of classifying specimens of this period, but by the end of the ninth fetal month the organ has certainly acquired two-thirds of its birth weight.

The relative weight of the stomach, that is, the per cent. which the organ forms of the entire body weight, seems to show no consistent change in prenatal life, although we encounter considerable variations in the monthly average in this as in all other organs. The relative weight in the latter part of the third fetal month is 0.250, and in the new-born 0.225. In the tenth fetal month this falls as low as 0.190, and in the fourth month it rises to 0.330, but these variations show no constant trend either above or below the general average of about 0.250 for the entire fetal period. They are probably to be regarded as due to fluctuations in the body weight rather than to changes in the rate of the stomach growth as compared with that of the growth of the body as a whole.

In the full-term new-born the average weight of the stomach is approximately 6.5 gm., which is somewhat more than 0.2 of 1 per cent. of the total weight of the body. This weight is the average of 167 cases. The variation from this average in individual cases is very great and stomachs weighing as little as 4 gm. or as much as 8 gm. are not uncommon in apparently normal and full-term new-born children.

The growth of the stomach in postnatal life is quite different from that of most of the organs of the body. The increase of the body in weight from birth to early maturity is generally in the neighborhood of twenty fold or a little more. Most of the larger viscera, such, for example, as the liver, the heart, the kidneys and the spleen increase about twelve times in weight in the same interval. In other words, the growth rate of these viscera is but little more than one half that of the entire body in the period between birth and the early part of the third decade. The stomach, on the other hand, increases from an average weight of 6.49 gm. at birth to an average weight of 154.5 gm. in the adult, or nearly twenty-four fold. Thus its growth rate in postnatal life is about twice that of many of the larger organs and is equal

to or a little greater than that of the body as a whole. So far as I am aware, only two other organs of the body approach the stomach in rate of postnatal growth. These are the parotid glands and the pancreas. But the growth of the parotid glands does not equal that of the stomach; and that of the pancreas, while approaching it, takes place at a somewhat different period in postnatal life. These peculiarities of the stomach's growth in postnatal life are illustrated in Tables 1 and 2 and by the graphs in Figures 2 and 5, inclusive. Start-

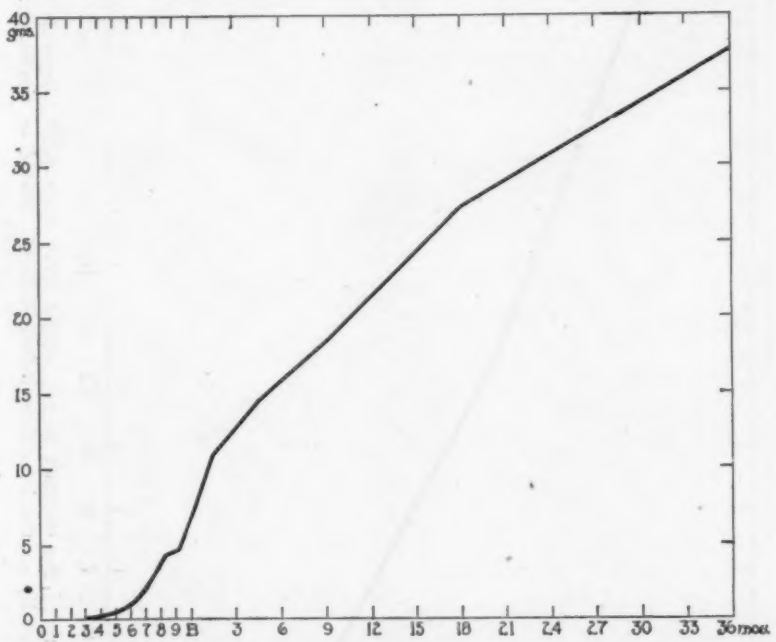

Fig. 2.—A curve illustrating the growth in the net weight of the stomach from the third fetal month to the close of the second year. Abscissa: age in months (fetal or postnatal); ordinate: weight of the stomach in grams. The point "B" on the base line indicates birth. Based on the material presented in Table 1.

ing with an average natal weight of about 6.5 gm., the stomach increases to an average weight of nearly 11 gm. in the first trimester, and a weight of about 14 gm. in the second trimester. The average weight in the second half of the first year is over 18 gm. In the second year the average weight of the organ is approximately 27 gm., and in the third and fourth years nearly 40 gm. Thus, the stomach more than doubles its weight in the first six months, and triples it by the end of the first year. By 2 years of age the birth weight of the organ has been increased about fivefold. By far the most rapid growth period is in the first trimester after birth.

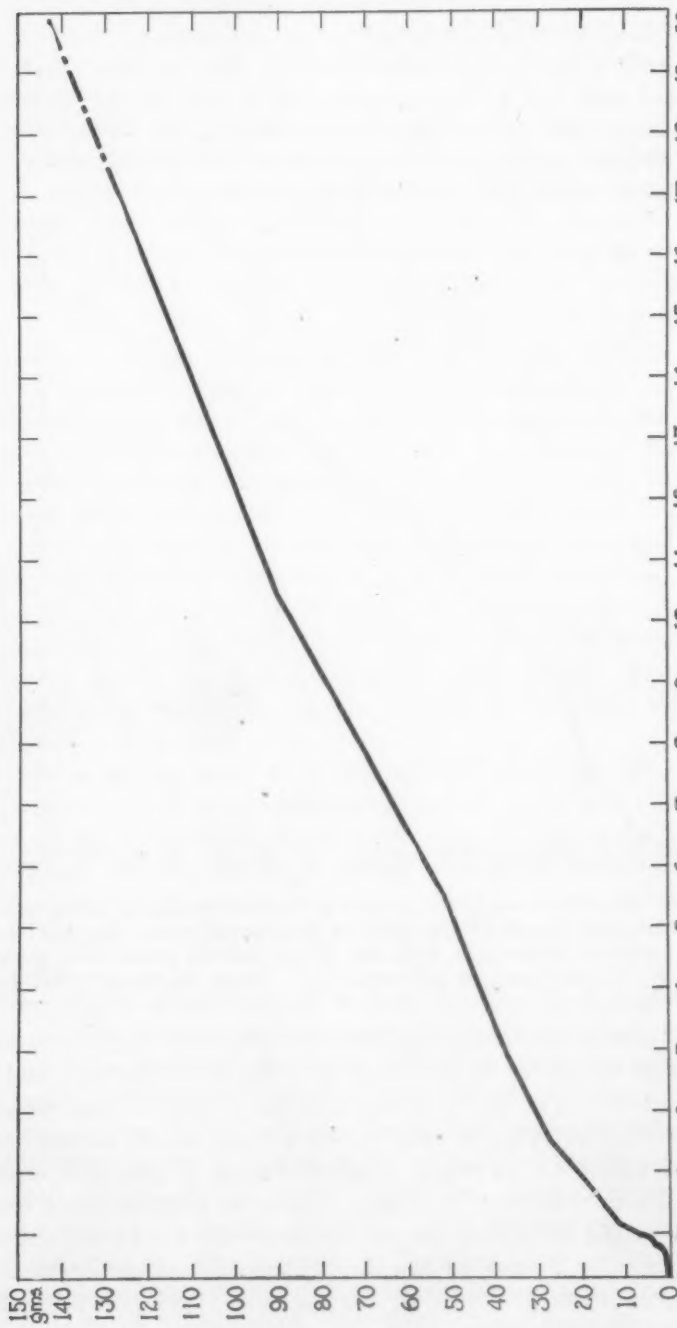

Fig. 3.—A curve illustrating the growth of the stomach in net weight from early fetal life to 20 years. Abscissa: age in years; ordinate: stomach weight in grams. B, on the base line, indicates birth. Based on the material presented in Table 1.

The growth of the stomach in net weight from infancy to maturity is illustrated by the curve shown in Figure 3. As seen in this figure, the rapid weight increment of infancy is much reduced after the first two years, although the organ continues to increase in weight throughout the first and second decades. There is apparently a slight drop in the rate of absolute growth about the close of the first period of

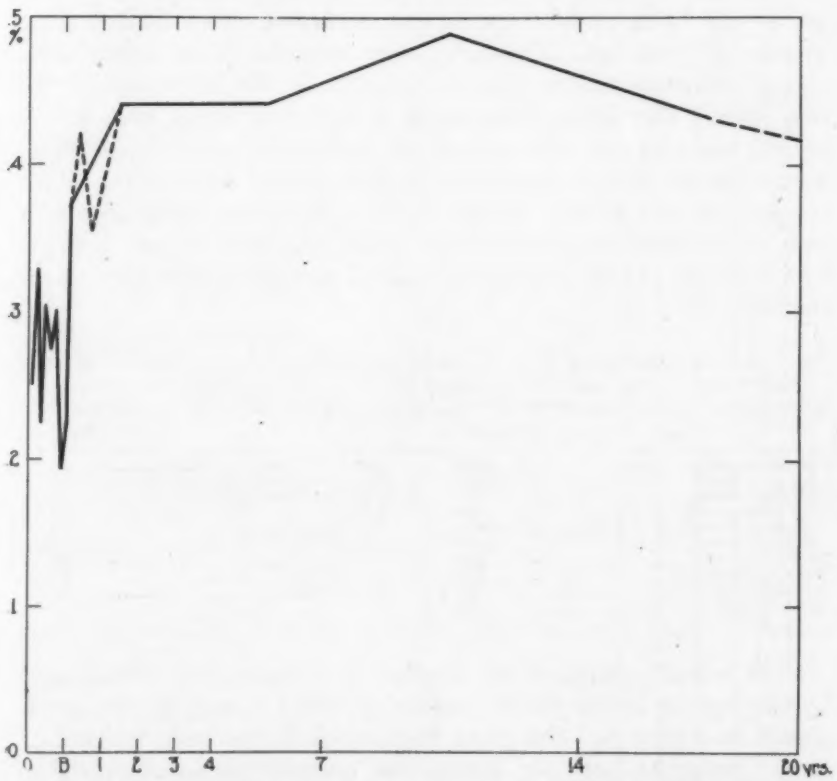

Fig. 4.—A curve illustrating the changes in the relative weight of the stomach from the third fetal month to 20 years. Abscissa: weight of the stomach in per cent. of the total body weight. Ordinate: age in years. Based on the data presented in Table 1.

childhood and a slight increase in the years before puberty. These changes would probably be seen in a more pronounced fashion were the material arranged in smaller time units, as similar changes are noticeable not only in most curves of the growth of the body as a whole, but also in curves of the growth in weight of many of the organs.

The rate of percentage weight increment, that is, the percentage of its weight which the stomach gains in a given period, is shown in

Table 2. In this table the percentage increment is calculated on the basis of the month. These calculations are based on values which have been determined from the originals of the graphs shown in Figures 1, 2 and 3, and are therefore only approximations. But they are sufficiently accurate to illustrate the general changes in the rate of increment which take place in fetal and postnatal life.

The rate of increment in the first trimester is about 31 per cent. per month, being about three fourths that observed in the last three months of fetal life. This rate drops to about 9 per cent. in the second trimester and to about 5 per cent. in the latter half of the first year. This again decreases to a little over 2 per cent. in the second year and to a little over 1 per cent. in the remainder of childhood. In the second decade the average rate of increment is about 0.5 per cent. per month. So far as I am aware, the continuance of a rate of increment approaching that of the last fetal months into the first trimester of postnatal life is found in no organ of the body except the stomach.

TABLE 2.—APPROXIMATE RATE OF MONTHLY INCREMENT IN STOMACH WEIGHT DURING FETAL AND POSTNATAL LIFE (CALCULATED FROM GRAPHS)

Age	Per Cent.	Age	Per Cent.
4th fetal month	100.0	9 to 12 months	5.1
5th fetal month	100.0	12 to 18 months	4.7
6th fetal month	62.0	18 to 24 months	2.2
7th fetal month	50.0	2 to 3 years	1.9
8th fetal month	43.0	3 to 4 years	1.2
9th fetal month	40.0	4 to 5 years	1.0
10th fetal month	44.0	5 to 10 years	1.3
Birth to 3 months	31.0	10 to 15 years	0.5
3 to 6 months	8.8	15 to 20 years	0.4
6 to 9 months	5.3		

The relative weight of the stomach in postnatal life is illustrated by the figures in the fourth column of Table 1, and by the graph shown in Figure 4. The great fluctuations in the body weights of cases coming to necropsy makes this quantity somewhat variable, particularly in early childhood. In the new-born the relative weight of the organ is 0.225. This is almost doubled in the first six postnatal months, rising to 0.417. In the second half of the first year the relative weight apparently drops again to 0.352, but this decline is probably due to the nature of the material in the particular cases which were examined rather than to an actual constant change in the relation of stomach weight to body weight in all cases of this period. After the first year the relative weight advances slowly to nearly 0.5 per cent. at puberty. Thereafter a decrease sets in which eventually reduces the maximum relative weight of puberty by about one third. The relative weight of the adult stomach averages 0.309, being about one fourth more than that of the new-born.

The general scheme of the growth of the stomach in net weight from early fetal life until full maturity is illustrated by Figure 5. This is a diagram showing the weight of the stomach at various ages, calculated on the basis of the weight of the organ in the new-born. The shaded square on the base line of the diagram represents the weight of the stomach in the new-born, which is considered as one; and the columns to the left and right represent the comparative weight of the organ in fetal and postnatal life.

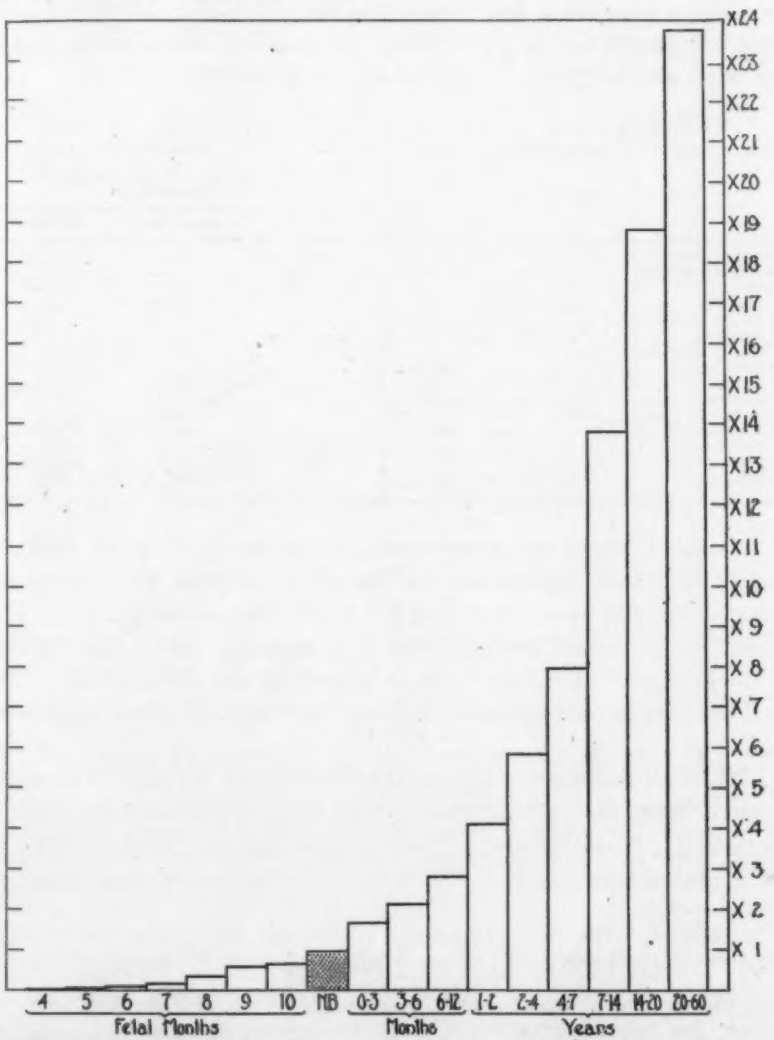

Fig. 5.—A diagram illustrating the weight of the stomach at different periods in fetal and postnatal life as compared to the average weight of the organ in the new-born infant. The weight of the stomach in the new-born is considered as 1 and is represented by the shaded square in the diagram.

2. THE GROWTH IN SURFACE AREA OF THE GASTRIC MUCOUS MEMBRANE

The data on the growth of the internal surface area of the stomach are scanty. Table 3 gives the available statistics on this subject. The first work on this phase of the stomach's growth was done by Toldt[7] in connection with a study of the development of the gastric glands. He found that the area of the internal surface of the stomach of a fetus of the eighth month was 23.02 square centimeters, and that this area was a little more than doubled in the new-born. At 10 years the area was nearly ten times, at fifteen years about eleven times, and in the adult nearly fifteen times that of the new-born.

TABLE 3.—AREA OF THE INTERNAL SURFACE OF THE STOMACH

Age	Area (in Sq. Cm.) of Internal Surface of Stomach Wall		
	Toldt[7]	Lissenko[8]	Dargien[9]
8th fetal month	23.02	.....	.....
10th fetal month	53.30	.....	.....
Birth	52.70	26.9	12.75
2 months	.....	60.2	31
3 to 3½ months	.....	67.7	48
5 months	.....	.....	55
6½ to 7 months	.....	85.7	67
8 months	.....	.....	82
9 months	.....	125.7	.....
11 months	.....	.....	118
1 year	.....	133.9	.....
3 years	.....	142.9	.....
10 years	505.1	.....	.....
15 years	657.7	.....	.....
Adult	763.0	454.7	600

Lissenko[8] found the gastric area of the new-born to be approximately 27 square centimeters, or about half as great as Toldt's estimate. This area more than doubled in the first trimester, more than tripled in the second trimester and was increased fivefold by the end of the first year. Between 1 and 3 years there was little growth. The total increase in area between birth and maturity was about seventeenfold.

The most extensive series of observations on the gastric area are those of Dargien.[9] His figures for early infancy are much lower than those of Toldt and Lissenko. In the new-born the average area was 12.75 square centimeters. This was increased nearly four times in

7. Toldt, C.: Die Entwicklung und Ausbildung der Drüsen des Magens, Sitzungsber., math.-naturwiss. Cl., k. Akad. Wissensch., Wien., 1881, Section 3, p. 57.

8. Lissenko, W.: The Growth and Structure of the Stomach in Childhood, Dissert. St. Petersburg, 1899. (Quoted from review in Jahresb. f. Anat. **3**: 1900, and from Gundobin, A. P.: Die Besonderheiten des Kindesalters, Berlin, 1912, p. 264 et seq.)

9. Dargien, P.: Surface et volume comparés du l'estomac et du duodenum, Bibliogr. anat. **12**:207, 1899.

the first trimester and five times in the first half year. By the eleventh month the natal area had increased nearly ten times, and by maturity nearly fifty times.

Although considerable differences exist between the figures of Lissenko and Dargien as to the actual area of the gastric mucous

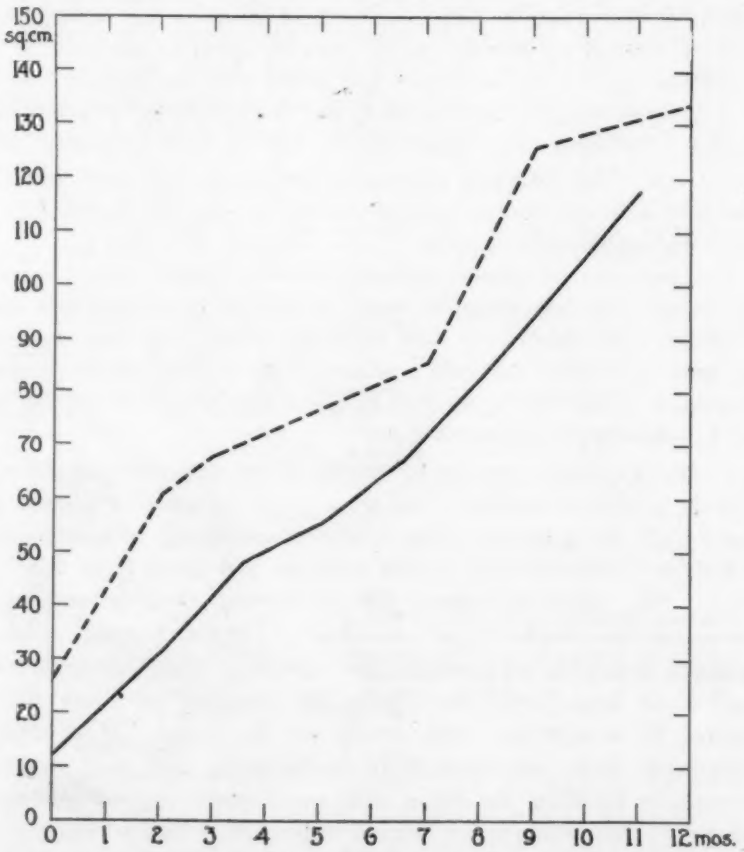

Fig. 6.—Curves illustrating the growth in surface area of the gastric mucous membrane during the first year. Abscissa: area of the gastric mucous membrane in square centimeters; ordinate: age in months. The upper curve (drawn in broken line) is based on the observations of Lissenko.[8] The lower curve is based on the observatoins of Dargien.[9]

membrane, Figure 6 shows that the curves of growth of the area based on these data are of much the same type. In both cases there is a steady and probably fairly regular growth during the first year. Many more data, particularly for the latter part of childhood, are necessary before further conclusions can be drawn on this subject.

3. THE GROWTH OF THE STOMACH IN CUBIC CAPACITY

The growth of the stomach in cubic capacity is obviously much more difficult to determine than either the increase of the organ in weight or the growth of its internal surface area. In the first place, there is no precise criterion of what constitutes a normally filled stomach. Second, no method yet devised of measuring gastric capacity is free from possible error. And third, as has been pointed out by a number of writers, gastric capacity depends not only on the chronologic age of the individual, but on the previous feeding history, the degree of physical development, and the individual physical constitution. In some cases these factors may be more important than that of age. The following material is presented with these points in mind and with the realization that conclusions can be drawn from it only with considerable caution.

The statistics on gastric capacity are very much more extensive than those regarding either stomach weight or gastric surface area. A number of methods have been employed in securing these data, but they may be divided into two general classes — the anatomic and the physiologic. The results secured by these two classes of technic will first be considered separately.

1. *The Anatomic Capacity of the Stomach.*—A number of different methods have been employed for testing the anatomic or postmortem capacity of the stomach. The earlier investigators (Fleischmann,[10] Froloffski[11]) distended the organ with air and dried it in this condition. The cubic capacity of the viscus was then determined by measuring the displacement in water. Drewitz[12] used similarly expanded stomachs, but measured the volume by filling the organ with small glass beads and determining the quantity of these objects required to occupy the entire cavity of the viscus. Most modern investigators have worked with fresh specimens and have measured the capacity by filling the organ with water under various conditions, with an eye to securing its normal expansion. Holt[13] removed the stomach from the body and filled it with water until the rugae were no longer visible when the organ was held before a strong light. Mosenthal,[14] leaving the organ in situ, ligated the pylorus and introduced water through the cardiac orifice at a pressure of about 15 cm.

10. Fleischmann: Klinik der Pädiatrik, Wein., 1875.
11. Froloffski: Material on the Anatomy of the Digestive Tract in Sucklings, Diss., St. Petersburg, 1876. (Quoted from summaries by Pfaundler, Footnote 2, and from review in Jahresb. f. Anat., 1877.)
12. Drewitz: Der Saüglingsmagen, Dissert., München., 1891.
13. Holt, L. E.: Observations on the Capacity of the Stomach in Infancy, Arch. Pediat. **7**:960, 1891; Diseases of Children, New York, Ed. 1, 1897.
14. Mosenthal, H.: Gastric Capacity of Infants, Arch. Pediat. **36**:261, 1909.

until it would hold no more. The organ was then clamped and removed from the body and its contents measured.

Probably the best method for the routine determination of gastric capacity is that devised by Zuccarelli.[15] He removed the organ from the body, distended it with water and then placed it in a vessel of water and opened its orifices. After the pressures of the fluid within and without the organ had adjusted themselves the orifices were again closed, the organ removed from the vessel, and its contents measured. This ingenious method has been extensively employed by a number of French observers, particularly by d'Astros,[16] and by Alliot.[17]

TABLE 4.—A Summary of Observations on the Anatomic Capacity of the Stomach. (Only a Portion of Pfaundler's Results Are Contained in the Table)

Observer	Fetal Months						Postnatal Weeks							Postnatal Months											Years								
	5th	6th	7th	8th	9th	lb.	1st	2nd	3rd	4th	5th	6th	7th	8th	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	3	4	5	6	7	8	10
Politzer, '58									51-65																220							
Fleischmann, '75	15				30		46	75	101	77		80					250	260				375										
Stössl, '75						40-50		60-70		70-80		125-145																				
Froloffsky, '76							50	75	105	122		156			167	178	180					233										
Beneke, '80						35-45		153-160				240																				
Drewitz, '90								99	150			115			130	165	253	297	217	289	310	351	535	500	502	500	689	1216				
Holt, '90						34		42		57		74		96	120	132	141	154	168	198	189		238	213	252							
Zuccarelli, '94	7.5	12	13	16	27		37	68	99	45	84	84	85	98	139	139	204		300	190	215		470	399	480	405	510	652	865			960
d'Astros, '94	5-10							59		75			85				147				287				360	500	600					770
Rolch, '95						25	25	40		75					100	107	114		220						300							
Muggia, '96		10				25		70-80				100																				
Pfaundler '97-'98	0	D				8.08				50				51	53	55	57-	60	64	68	75	82	90	100	125	140	150	159	167	174	180		
		S													13	8	9	10	11	13	16	21	27	36	46	53	59	64	68	71	73		
	15	D																														
		S								90				100	110	125	140	160	180	200	225	250	275	290									
	20	D				17				120				140	170	200	230	260	290	325	360	395	430	460	585	680	760	830	890	940	980		
		S													140	165	190	215	245	275	305	335	365	370	490	575	640	700	750	800	840		
	30	D				30.8				150				175	200	230	260	295	330	365	405	445	485	515	640	730	810	880	935	970	930		
		S													210	235	260	290	325	360	395	430	460	490	620	730	820	890	945	905	1000		
Dargein, '99						34									95	120	140		145	215			240										
Lissenko, '99															55-145	65-190																
Flacher, '00										60									256				300									
Alliot, '05		14-17	20.2	24.5	27	35																										
Moserithal, '09										76	50	74	70		52	68	74		124													

Although Muggia[18] was apparently the first observer to test the capacity of the excised stomach at a definite pressure, by far the most complete investigation of this kind is the well known one of Pfaundler.[19] He measured the capacities of the stomachs of a series of children from birth to 8 years of age at pressures varying from

15. Zuccarelli, P.: L'estomac de l'enfant, Thèse Paris, 1894.

16. d'Astros: L'estomac de l'enfant; sa dilatation, Rev. de mal. de l'enf. **12**: 1894.

17. Alliot, L.: Le capacité stomacale du nouveau-né, Thèse Paris, 1905.

18. Muggia, A.: La capacitè e la posizione del ventricolo nei bambini, Giorn. d. r. Accad. di med. di Torino, Series 4, **2**:351, 1896.

19. Pfaundler, M.: Ueber Magencapacität im Kindesalter, Wein. klin. Wchnschr. **10**:961, 1897. Ueber Magencapacität und Gastrectasie im Kindesalter, Biblioth. med. Sec. 4, Part 5, 1898.

0 to 30 cm. of water. Pfaundler concluded that a pressure of about 15 cm. of water produced a distention of the contracted or systolic stomach most comparable with the filled stomach of the living child.

The results of the application of these various methods by different observers are shown in Table 4. An examination of this table shows that while there is much variation in the individual cases, the findings of these several observers, taken as a whole, are in fair agreement, particularly for the period between birth and the eighth or ninth month. Also, if one may judge from the conclusions of Muggia and Pfaundler regarding gastric capacity at different pressures, most investigators, regardless of the method which has been employed, have secured a distention of the stomach equal to or a little greater than that obtained with a pressure of 15 cm. of water.

On the basis of the data presented in Table 4 I have constructed a semidiagrammatic curve illustrating the changes in gastric capacity as determined by all anatomic methods for the period from the fifth fetal to the tenth postnatal month. This curve is shown in Figure 7. An examination of this curve shows that it is divisible into five distinct segments which represent periods in which the increase in gastric capacity, in as far as it may be determined by anatomic methods, differs considerably. Starting at the first fetal month, the capacity of the stomach is approximately 10 c.c. This rises to about 20 c.c. by the middle of the sixth fetal month, but thereafter the increase until the close of prenatal life is rather slow. In the full-term new-born the average capacity is between 30 and 35 c.c. Immediately after birth the curve enters its third phase and shows a rapid rise for about four weeks. At the end of this period the capacity is about 100 c.c., or about three times that of the child at birth. A second period of slow increase follows from the end of the first postnatal month until nearly the close of the third trimester. During this interval the gastric capacity is slightly more than doubled. The actual rate of increase is about 30 per cent. per month, or about one tenth that observed in the first four weeks. At the beginning of the eighth month the curve again begins to rise rapidly. How long this second period of rapid increase continues our data are insufficient to determine, but it is probable that it does not extend far past the end of the first year.

The data on the increase in the anatomic capacity of the stomach in later childhood are less extensive than those regarding the growth in the first year. The figures assembled in Table 4 indicate that the average capacity in the second year is not far from 500 c.c., in the third year about 550 c.c., and in the fourth year about 600 c.c. In the latter half of childhood the average gastric capacity probably lies

between 750 and 950 c.c. Apparently there are no data on the capacity of the stomach in adolescence. A large number of observations on the capacity of the adult stomach, as determined by a number of anatomic methods, have been published by Charbrie,[20] Dargien,[9]

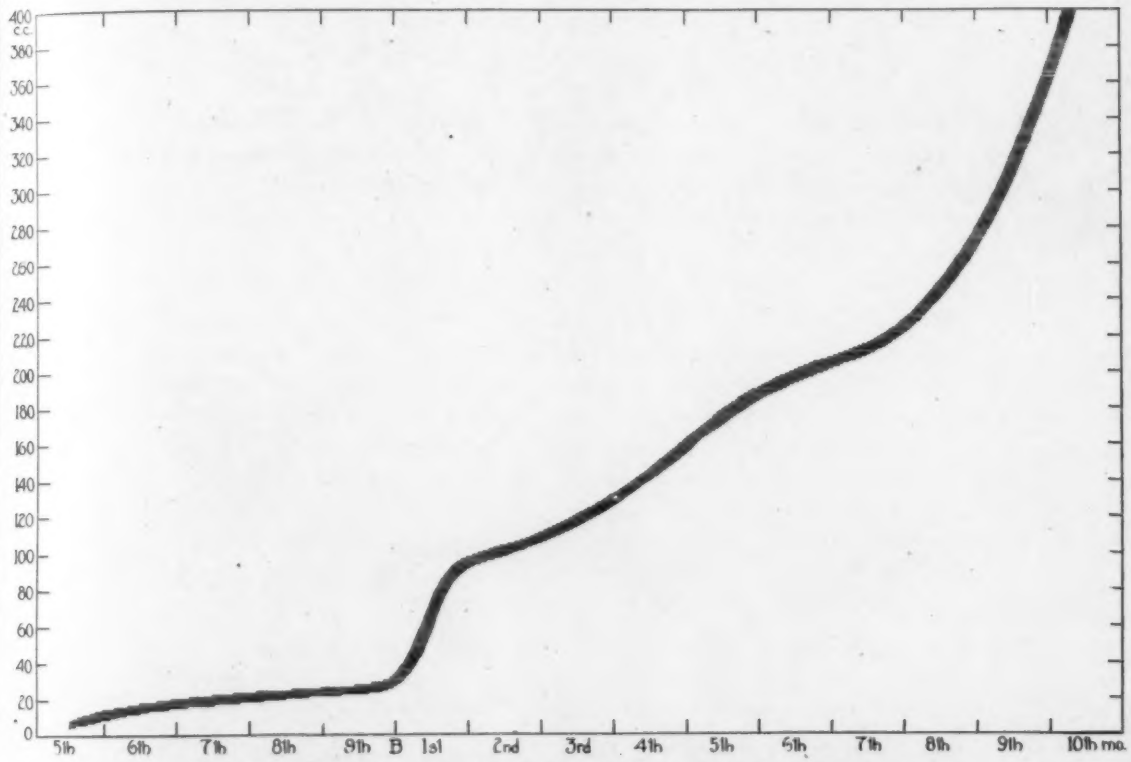

Fig. 7.—A semidiagrammatic curve illustrating the increase of gastric capacity during fetal life and in the first year as determined by all anatomic methods. Abscissa: age in fetal or postnatal months; ordinate: capacity of the stomach in cubic centimeters. Based on the material presented in Table 4 (with the exception of the data of Pfaundler).

Legendre,[21] Ost,[22] Pfaundler,[19] Sugari,[23] and others. These studies show great individual variations in the capacity of the organ in maturity, but the more extensive series of observations, such as those of Dargien and Legendre, indicate that the usual and the average capacity of the excised stomach, when moderately distended, lies

20. Charbrie: Thèse Toulouse, 1894.
21. Legendre: Thèse Paris, 1886.
22. Ost, A.: Beiträge zur Bestimmung der Capacität des Magens, Dissert. Dorpat, 1891.
23. Sugari, T.: Ueber die Lage und Kapazjtät des Magens bei Japanern, Centralbl. f. allg. Path. **20**:390.

between 1,200 and 1,600 c.c. The figures of Pfaundler on the capacity of the stomach at all pressures are much above those just quoted, but his observations were made on diastolic stomachs. Accepting the figures offered in the foregoing, it appears that the increase in the anatomic capacity of the stomach between birth and maturity is forty or fifty-fold, or about twice as much as the increase of the organ in weight.

2. *The Physiologic Capacity of the Stomach.*—Two methods have been employed in the study of gastric capacity in the living. The first and usual one is to determine the amount of food ingested by weighing the child before and after feeding; and the second is to measure the amount of air introduced into the stomach at a definite pressure by means of a tube connected with a cylinder which may be raised and lowered into a vessel of water. As the cylinder is graduated it is possible to determine how much air is driven from it into the stomach at a given pressure. The second method, which was devised by Jaworski[24] and Kelling,[25] has been developed and applied to the study of gastric capacity in children by Pfaundler.[19] While the results obtained by this method are of great interest, they are hardly extensive or conclusive enough to warrant their graphic analysis at present. The familiar method of determining gastric capacity by weighing the child before and after feeding was apparently first systematically employed by Guillot,[26] although it is difficult to believe that such an obvious procedure was not in use long before this time. Since this date an enormous amount of data obtained by this method has been published. However, much of the earlier work in this field is of no great value because of the short feeding intervals employed by the first observers.

The findings regarding the capacity of the stomach as determined by the method of weighing before and after feeding may be divided into two groups. The first, and by far the most extensive, are those of the average amount of food ingested at a single feeding. The second, of which there are comparatively few published records, are of the maximum amount of food ingested at a single feeding in a given period. The former have by far the greater practical importance, but as Feer[27] and others have pointed out, the maximum feeding is probably a better index of possible gastric capacity.

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24. Jaworski, W.: Ueber Anwendung der Gase für therapeutische und diagnostische Zwecke bei Magenkrankheiten, Deutsch. Arch. f. klin. Med. **35**:79, 1884.

25. Kelling, G.: Ein einfaches Verfahren zur Betimmung der Magengrosse mittels Lust, Deutsch. med. Wchnschr. **18**:260 and 1191, 1892.

26. Guillot, N.: De la nourrice et du nourrisson, Union méd., 1852, p. 61.

27. Feer, E.: Beobachtungen über die Nahrungsmengen von Brustkindern, Jahrb. f. Kinderh. **42**:195, 1896.

Some of the better known determinations of the average capacity as found by the average feeding method are shown in graphic form in Figure 11. These will be considered in detail in another part of this article, but it may be pointed out at this time that the curves based on these determinations are all of practically the same type and that their divergences are probably due to the nature of the material and slight differences in method employed by the various observers.

Apparently, the first data on the maximum capacity of the stomach in infancy were published by Ahlfeld[28] in 1878. This author bases his tables on the maximum feeding in each weekly period of the time in which his cases were under observation. Later workers have followed Ahlfeld in the use of this time unit in determining the maximum physiologic capacity. More material of this kind was published by Haehner[29] and by Feer.[27] The latter published a table giving the average maximum capacity of seven cases, three of his own and four observed by Ahlfeld and Haehner. Feer's summary is the only one of the kind which has been published.

A considerable number of observations on the maximum physiologic capacity of the stomach have appeared in the literature since Feer published his summary, and a complete list of the published feeding histories of children which extend over a number of weeks and include a record of the amount of food ingested at each meal would now probably contain over twenty cases. From the available data of this kind I have selected eleven cases and have prepared a summary of the average and maximum feedings for each week from birth to the close of the seventh month. This list has been limited to children having at least an average birth weight, who have shown a normal gain in weight during the period of observation, and who, for the greater part of the period at least, were breast fed. This summary is given in Tables 5 and 6, and the graphs shown in Figures 8, 9 and 10 are based on this material. Brief histories of these eleven cases are given:

REPORT OF CASES

Histories of eleven children whose feeding records are summarized in Tables 5 and 6, and are shown in graphic form in Figures 8, 9 and 10.

Case 1.—(Selter.[30]) Male; birthweight, 3,250 gm.; birthweight recovered on thirteenth day; weight at end of fourth week, 3,840 gm.; eighth week, 4,800 gm.; tenth week, 5,310 gm.; sixteenth week, 6,390 gm.; nineteenth week,

28. Ahlfeld, F.: Ernährung des Saüglings, Leipzig, 1878.
29. Haehner, H., and Pfeiffer: Festschr. f. E. Henoch, 1890, p. 90 et seq.
30. Selter, P.: Nahrungsmengen und Stoffwechsel des normalen Brustkindes, Arch. f. Kinderh. **37**:91, 1903.

6,980 gm.; seven feedings per day; breast feeding throughout period of observation.

CASE 2.—(Paffenholz.[31]) Female; first child; birthweight, 3,430 gm.; birthweight regained on twenty-seventh day; weight at end of fourth week, 3,490 gm.; eighth week, 4,590 gm.; twelfth week, 5,520 gm.; sixteenth week, 6,490 gm.; twentieth week, 7,290 gm.; six or seven feedings per day; breast feeding until ninetieth day; thereafter mixed feeding.

CASE 3.—(Paffenholz.[31]) Male; second child; birthweight, 4,140 gm.; birthweight regained on tenth day. Weight at end of fourth week, 4,710 gm.; eighth week, 5,680 gm.; twelfth week, 6,520 gm.; sixteenth week, 7,140 gm.; twentieth week, 7,530 gm.; six feedings per day until middle of fourteenth week; five feedings per day until middle of sixteenth week; four feedings per day thereafter; breast feeding until end of thirteenth week; mixed feeding thereafter.

CASE 4.—(Feer.[27]) Male; second child; birthweight, 3,615 gm.; birthweight regained before end of third week; weight at end of fourth week, 4,165 gm.; eighth week, 5,369 gm.; twelfth week, 6,153 gm.; sixteenth week, 6,864 gm.; twentieth week, 7,399 gm.; twenty-fourth week, 7,748 gm.; twenty-eighth week, 8,022 gm.; breast feeding until 216th day; thereafter mixed feeding; seven feedings per day for first two weeks; thereafter five, six or seven feedings.

CASE 5.—(Feer.[27]) Female; first-born; birthweight, 3,765 gm.; birthweight regained in fifth week; weight at end of fourth week, 3,780 gm.; eighth week, 4,525 gm.; twelfth week, 5,160 gm.; sixteenth week, 5,550 gm.; twentieth week, 6,030 gm.

CASE 6.—(Haehner.[32]) Male; second-born; birthweight, 2,950 gm.; birthweight regained seventh day; weight end of fourth week, 3,580 gm.; eighth week, 4,505 gm.; eleventh week, 5,045 gm.; feedings rather irregular; generally seven per day until end of eighth week, although on some occasions nine per day, and on some five; ninth week and thereafter generally six feedings per day; breast feeding throughout.

CASE 7.—(Haehner[33]) Female; first-born; birthweight, 3,100 gm.; birthweight regained on ninth day; weight at end of fourth week, 3,607 gm.; eighth week, 4,793 gm.; twelfth week, 5,636 gm.; twentieth week, 6,370 gm.; twenty-fourth week, 5,650 gm.; twenty-eighth week, 7,300 gm.; thirty-second week, 7,830 gm.; generally five feedings per day, although sometimes four or six, until close of eighteenth week; thereafter generally four feedings, although five not unusual; breast feeding until close of twenty-third week; thereafter mixed feeding.

CASE 8.—(Selter.[29]) Male; second child (?); birthweight, 2,870 gm.; birthweight regained on tenth day; weight at end of fourth week, 3,580 gm.; sixth week, 4,030 gm.; tenth week, 4,760 gm.; thirteenth week, 5,250 gm.; twentieth week, 6,120 gm.; six feedings, or occasionally five per day; breast feeding throughout.

CASE 9.—(Biermer.[34]) Sex and parity not stated; birthweight, 3,850 gm.; weight at end of second week, 3,830 gm.; fourth week, 3,950 gm.; eighth week, 4,420 gm.; twelfth week, 4,880 gm.; sixteenth week, 5,550 gm.; twentieth week, 6,440 gm.; twenty-fourth week, 7,090 gm.; twenty-eighth week, 7,710 gm.; thirty-second week, 8,330 gm.; five feedings per day throughout period; breast feeding until twenty-sixth week; thereafter mixed feeding.

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31. Paffenholz: Beitrag zur Kenntniss der Nahrungsmengen natürlichen ernahrten Sauglinge, Arch. f. Kinderh. **37**:104, 1903.

32. Weitere Beobachtungen über die Nahrungsaufnahme des Kindes und das Wachsthum in ersten Lebensjahre, Jahrb. f. Kinderh. **21**:289, 1884.

33. Haehner, H.: Ueber die Nahrungsaufnahme des Kindes an der Mutterbrust und das Wachsthum in ersten Lebensjahre, Jahrb. f. Kinderh. **15**:23, 1880.

34. Biermer, R.: Beiträge zur Frage der naturlichen Ernahrung, Arch. f. Kinderh. **47**:68, 1908.

Case 10.—(Biermer.[34]) Parity and sex of child not stated; birthweight, 3,750 gm.; birthweight regained at end of third week; weight at end of fourth week, 3,890 gm.; eighth week, 4,250 gm.; twelfth week, 4,710 gm.; sixteenth week, 5,085 gm.; twentieth week, 5,700 gm.; twenty-fourth week, 6,310 gm.; twenty-eighth week, 6,830 gm.; thirty-second week, 7,107 gm.; five feedings throughout period; length of feeding, ten minutes; breast feeding until end of thirty-first week.

Case 11.—(Ahlfeld.[28]) Weight at end of fourth week, 3,620 gm.; eighth week, 4,400 gm.; twelfth week, 5,170 gm.; sixteenth week, 6,220 gm.; twentieth week, 6,957 gm., 7,700 gm., 8,325 gm.; thirtieth week, 8,580 gm.

TABLE 5.—Physiologic Capacity of the Stomach as Determined from the Amount of the Average Meal in Eleven Selected Cases

Weeks	Capacities in Individual Cases (in grams*)											No. of Cases per Week	Average Capacity in All Cases, Gm.
	1	2	3	4	5	6	7	8	9	10	11		
1st	...	...	52	66	73	43	51	50	...	62	...	7	57
2d	74	...	95	81	89	66	67	70	...	111	...	8	82
3d	79	...	116	98	80	68	77	91	113	125	...	9	94
4th	87	73	131	122	88	81	94	102	130	131	104	11	104
5th	89	92	118	...	108	91	113	109	139	134	128	10	112
6th	99	102	127	...	111	98	144	117	150	133	150	10	123
7th	108	107	146	...	133	101	157	...	166	138	157	9	135
8th	116	119	145	...	132	109	162	...	152	131	163	9	136
9th	115	131	144	...	127	101	153	...	132	143	167	9	135
10th	120	144	162	...	132	98	159	131	126	152	164	10	138
11th	...	142	153	...	122	114	153	...	151	148	162	8	145
12th	...	145	155	...	126	...	171	...	168	148	173	7	155
13th	...	136	155	...	125	...	168	122	176	149	200	8	154
14th	...	151	153	...	122	...	175	...	179	151	200	7	161
15th	...	158	197	...	118	...	183	...	188	159	225	7	176
16th	123	150	...	...	110	...	156	...	181	157	212	7	157
17th	138	170	...	...	109	...	150	...	197	166	208	7	162
18th	161	169	...	...	109	...	176	...	190	162	241	7	171
19th	139	172	...	...	...	...	207	...	193	166	231	6	184
20th	...	173	...	...	...	...	198	115	202	166	212	6	178
21st	...	...	...	...	...	...	196	...	198	173	233	4	200
22d	...	...	...	...	...	...	190	...	197	173	200	4	190
23d	...	...	...	...	...	...	184	...	201	176	217	4	195
24th	...	...	...	...	...	...	157	...	199	178	214	4	187
25th	...	...	...	...	...	...	169	...	199	185	205	4	189
26th	...	...	...	...	...	...	188	...	205	179	207	4	195
27th	...	...	...	...	...	...	199	...	200	191	224	4	204
28th	...	...	...	...	...	...	219	...	208	198	215	4	210
29th	...	...	...	...	...	...	215	...	206	189	261	4	217
30th	...	...	...	...	...	...	220	...	197	182	263	4	216

* The cases are numbered in accord with the protocols given on pages 411 and 412.

The changes in the average intake per meal for each week from birth to 14 weeks in these cases is shown in graphic form in Figure 8. Figure 9 is a similar graph illustrating the changes in the maximum meal in the given week in the same cases. Both of these graphs illustrate the great individual variation to be expected in measurements of this kind, even when the material is limited to apparently healthy children having a normal birth weight. The curves as a whole, however, tend to gather in a fairly compact cluster, the upper and lower boundaries of which are rather regular. An examination of the protocols shows no particular relation between the weight of the child and the character of its feeding curve. Furthermore, there seems to be no close relation between the weekly average and the weekly maximum meal in the individual cases.

The curves shown in Figure 10 illustrate the average intake per single meal in all of the cases of the series and maximum single intake in a given week in all of these cases. The curves have been slightly smoothed by inspection. Both of these curves are of the same type. Both show a rapid rise in the first three weeks, and thereafter a much slower, but a constant elevation until the end of the period of observation. The values of the upper curve, of the maximum intake, are, however, from 40 to 65 per cent. higher than those of the lower curve

TABLE 6.—MAXIMUM PHYSIOLOGIC CAPACITY OF THE STOMACH AS DETERMINED FROM THE MAXIMUM MEAL OF EACH WEEK IN ELEVEN SELECTED CASES

Weeks	Capacities in Individual Cases (in grams*)											No. of Cases per Week	Average Maximum Capacity in All Cases
	1	2	3	4	5	6	7	8	9	10	11		
1st	...	45	120	120	125	85	124	110	...	120	...	8	106
2d	110	70	130	125	160	100	113	120	...	170	...	9	122
3d	110	100	160	145	135	125	170	140	170	180	...	10	143
4th	130	120	170	165	155	130	163	170	180	190	140	11	155
5th	130	140	170	190	220	160	187	250	200	200	160	11	183
6th	145	150	190	220	180	160	230	205	210	200	200	11	190
7th	180	150	230	195	200	160	218	...	250	210	210	10	200
8th	200	170	220	205	260	160	250	...	210	225	245	10	214
9th	180	195	220	205	190	180	255	...	180	240	250	10	209
10th	180	210	240	240	205	170	230	240	170	230	225	11	211
11th	...	180	225	230	190	170	245	...	240	230	245	9	217
12th	...	190	220	285	195	...	280	...	230	230	275	8	238
13th	...	200	220	280	190	...	290	250	270	240	350	9	254
14th	...	220	230	295	195	...	285	...	280	230	320	8	257
15th	...	210	250	290	190	...	280	...	270	230	300	8	245
16th	190	210	280	330	175	...	285	...	300	260	315	9	261
17th	270	230	290	300	170	...	290	...	340	250	330	9	270
18th	230	215	310	300	170	...	265	...	350	250	340	9	270
19th	210	250	280	320	...	...	290	...	310	260	315	8	279
20th	...	250	280	290	...	...	305	230	310	220	325	8	277
21st	...	..	...	310	...	...	310	...	360	250	335	5	313
22d	...	..	...	310	...	...	330	...	350	250	296	5	307
23d	...	...	...	290	...	...	320	...	340	260	350	5	312
24th	...	...	...	260	...	...	340	...	330	270	330	5	306
25th	...	...	...	300	...	...	270	...	330	260	290	5	290
26th	..	...	...	265	...	...	300	...	320	260	300	5	306
27th	...	...	...	275	...	...	300	...	310	280	345	5	302
28th	..	..	...	270	...	...	340	...	320	280	430	5	330
29th	...	...	...	355	...	...	275	...	320	250	400	5	322
30th	..	...	...	300	...	...	275	...	310	250	350	5	299

* The cases are numbered in accord with the protocols given on pages 411 and 412.

of average intake. We may conclude, therefore, in so far as it is possible to judge at all of gastric capacity from this type of observation, that the average or usual expansion of the stomach at a single meal in the first half year of life represents approximately two-thirds of the physiologic capacity of the organ, and that the average and the maximum physiologic capacity continue to grow at about the same rate during this period.

3. *A Comparison of the Findings Obtained by Anatomic and Physiologic Measures of Gastric Capacity.*—That many objections can be raised to the accuracy of the results obtained by either anatomic or physiologic measures of gastric capacity is very evident. As for the

former, they are applicable only to material which is often pathologic and of which the history is often incompletely known. The results might be expected to depend to a large extent on the condition of the stomach wall at the time of death and on the subsequent changes which it has undergone. There is, furthermore, considerable evidence

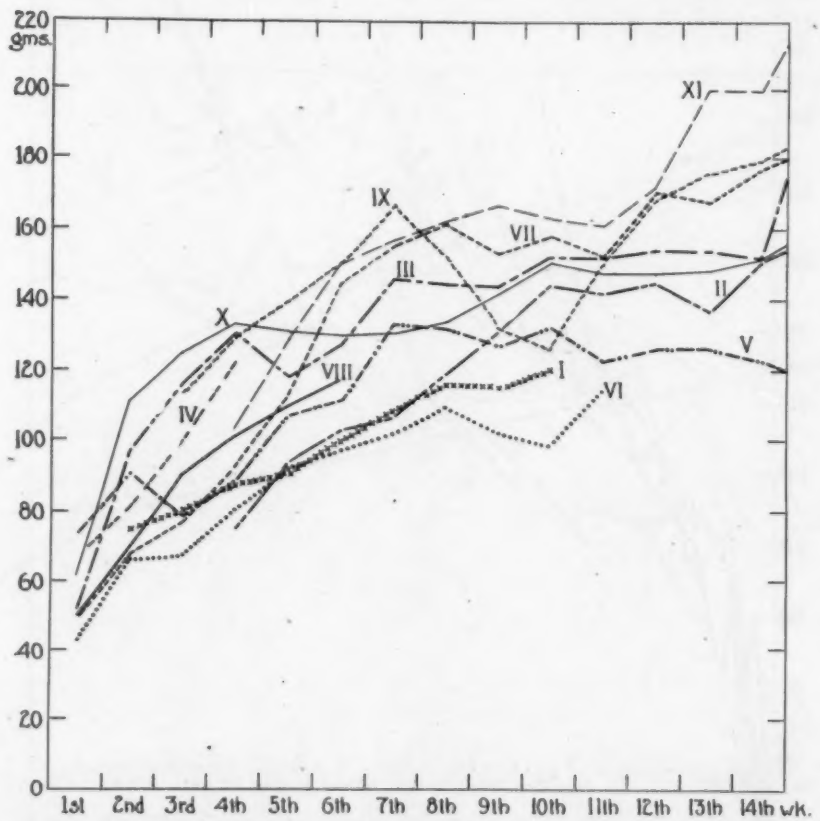

Fig. 8.—A series of curves showing the gastric capacity as determined by the average intake per single meal per week in the eleven selected cases on which the average curves shown in Figure 10 are based. The curves of the individual cases are numbered in correspondence with the protocols given on pages 411 and 412.

to show that the filling of the stomach in life is not a simple expansion of the organ following the pressure of its contents, such as is obtained in distending the organ postmortem by artificial means. The method of weighing the child before and after feeding is also open to criticism as a test of actual gastric capacity. The results are dependent to some extent both on the amount of milk available in the mammary gland of the mother, in cases of breast feeding, and on the infant's appetite.

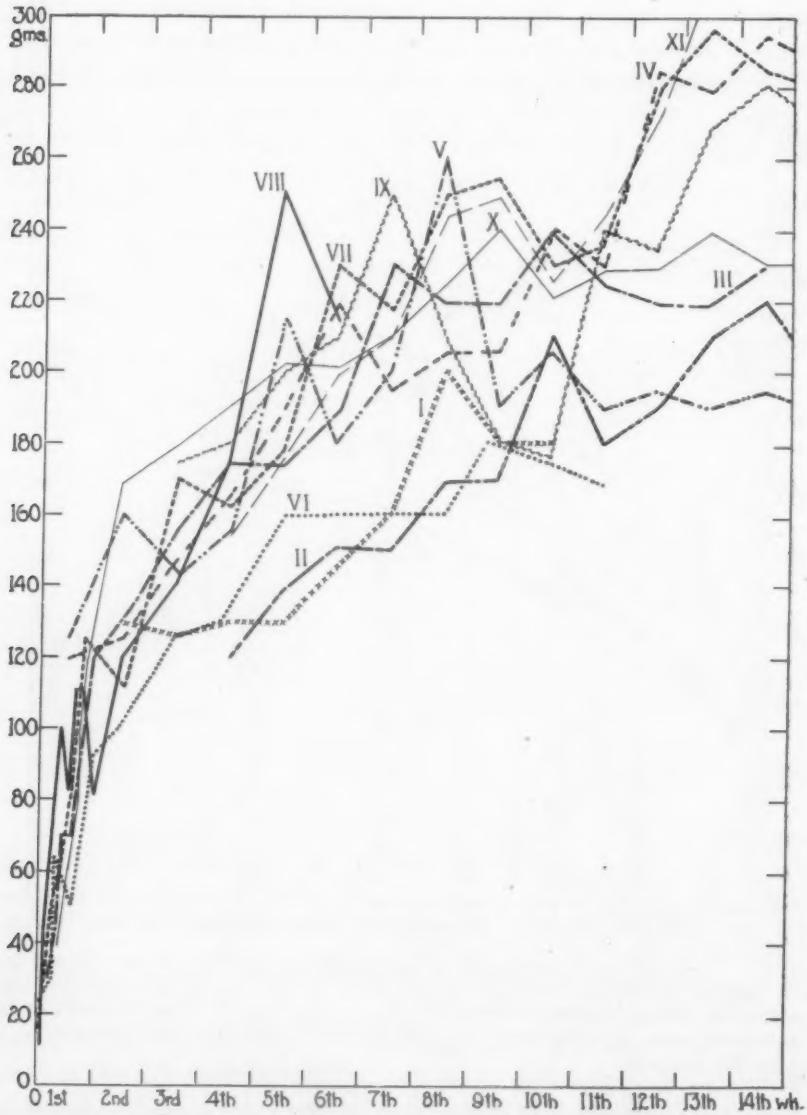

Fig. 9.—A series of curves illustrating the growth in gastric capacity as determined by the maximum single meal per week in each of the eleven selected cases, which have been combined to determine the average curve shown in Figure 8. The curves are numbered in correspondence with the cases in the protocols.

Again the roentgenographic studies of Levin and Barret,[1] Ladd,[35] Pisek and Lewald,[36] DeBuys and Henriques,[37] and others, have shown, first, that food is expelled through the pylorus very shortly after its ingestion, and secondly, that the rate of this expulsion is greatly affected, even in normal infants, by such factors as the nature of the food, posture of the body, etc. The early passage of food from the stomach will lead to an overestimate of gastric capacity by the feeding

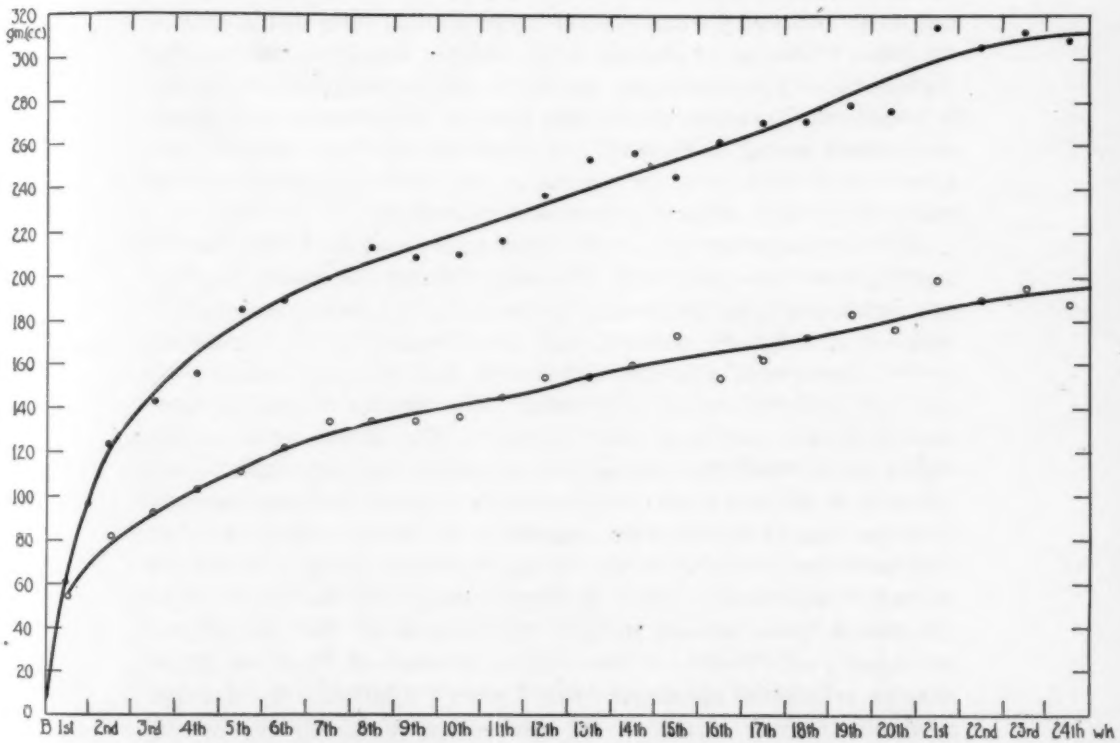

Fig. 10.—Two curves illustrating the increase of gastric capacity during the first six months as determined from the feeding records of the eleven selected cases on pages 411 and 412. The curves have been smoothed by inspection. The average points are indicated by dots or small circles. The upper curve is of the average maximum single meal in the week indicated. The lower curve is of the average intake per single meal in the week indicated. The segments of the curves falling in the period of the first week are based on the average and the maximum meal per day in so far as the data permitted.

35. Ladd, M.: The Influence of Variations of Diet on the Gastric Motility of Infants, Tr. Am. Pediat. Soc. **25**:81, 1912.

36. Pisek, G. R., and LeWald, L. T.: The Further Study of the Anatomy and Physiology of the Infant's Stomach Based on Serial Roentgenograms, Tr. Am. Pediat. Soc. **25**:150, 1913.

37. DeBuys, L. R., and Henriques, A.: Effect of Body Posture on the Position and Emptying Time of the Stomach, Am. J. Dis. Child. **15**:190, 1918.

method. On the other hand, the presence of the cardiac gas bubble and the loss of moisture from the lungs and skin during the feeding period will lead to an underestimate of the actual capacity of the organ. While these two groups of factors may in part balance one another, they are all variable to a degree.

Since evidently the present physiologic and anatomic methods can give but approximations of the actual gastric capacity, a comparison of their results is desirable in order to determine what correlation, if any, exists between them, and to eliminate possibly some of the sources of error. Such a comparison is particularly important because the application of the physiologic method of determining gastric capacity by measuring the amounts of single feedings is limited to a comparatively short period in infancy, and at present our knowledge of the growth of the capacity of the stomach in fetal life and in later childhood must rest on data secured by anatomic methods.

Two important studies of the relation of anatomic to physiologic capacity have been published. Pfaundler[19] tested the gastric capacity of a number of living children by his method of expanding the stomach with air at a known pressure, and also determined the postmortem gastric capacities of the same children by distending the stomachs in situ with water at a definite pressure. The number of normal cases studied in this way was rather limited. The results show a fair degree of correlation, although the anatomic capacity varied considerably in different cases, being sometimes greater and sometimes less than the capacity at the same pressure in the living. Pfaundler also compared the averaged results of his findings on the capacity of excised stomachs with other authors' averages of the capacity as determined by the feeding method. He pointed out that his data on the capacity of the excised stomach at a pressure of 30 cm. of water were in substantial agreement with Freer's[27] figures on the average maximum feeding capacity. He also compared his figures of the capacity of the stomach at a pressure of 15 cm. of water with Escherich's table of the amounts of average single feedings and found that the data obtained by the two methods were in fair agreement, although the anatomic figures were slightly lower in the first six months and higher in the last six months of the first year than were the physiologic.

Mosenthal[14] compared the physiologic capacities of twenty-four children with the anatomic capacities in the same cases. All of these children were fed on cow's milk at three-hour intervals. Their ages varied from 4 to 35 weeks. The anatomic capacities were determined by filling the stomach with water in situ at a pressure of 15 cm. Mosenthal found that in all instances, with the exception of children

with diastolic stomachs, the living child ingested more fluid than its stomach would hold postmortem. The average amount of milk taken at each feeding was 3.6 ounces and the average postmortem capacity was 2.6 ounces. Mosenthal therefore concluded that the physiologic capacity of the stomach was considerably greater than the capacity as determined by anatomic methods.

A further test of the relation between anatomic and physiologic capacity may be made by comparing graphically the results which have been obtained with the different modifications of the two methods. Such a comparison is shown in Figure 11, which contains a series of curves already presented in this paper, together with a number of curves based on some of the better known estimates of gastric capacity as determined by the feeding method. These curves are all drawn to a uniform scale.

Examining this graph it will be seen that the curves fall quite definitely into an upper and a lower group. The upper group is formed by the curve of the maximum feeding capacity, as determined from selected cases, and the curves based on Pfaundler's data on the capacity of the excised stomach at a pressure of 30 cm. of water (Curves I, III and IV, Fig. 11). All of the remaining curves gather closely together at a somewhat lower level in the first part of their course. They are all very similar for the segments representing the growth of capacity in the first six months and the maximum variation between them is only about 40 c.c. The curve based on the average intake per single feeding as determined from the eleven selected cases (Curve VII) is the highest of the group in the first segment of the graph, but this is later exceeded by the curve of anatomic capacity at a pressure of 20 cm. of water and by the curve of capacity as determined by all anatomic methods (Curves V and VI). The lowest curves for this period are first the one based on Holt's (X) figures for the average feeding, and later the curve based on Pfaundler's data on the capacity of the excised stomach at 15 cm. water pressure (Curve XIII).

The later part of the second group of curves, representing gastric capacity from six months to one year, do not show the close correspondence observed in the earlier period. The curve based on anatomic capacity as determined by all methods (Curve V) rises very rapidly after the seventh month. That based on Pfaundler's data on the capacity of the excised stomach at a pressure of 20 cm. of water also shows a rapid rise at about this period. The curves based on the feeding observations of Rotch,[38] (IX) Ladd[39] (VIII) and Holt (X),

38. Rotch, T. M.: Pediatrics, Philadelphia, Ed. 1, 1896, p. 79 et. seq.

39. Ladd, M.: Percentage Modification of Milk in Infant Feeding, Boston M. & S. J. **198**:5, 1903. Studies in the Nutrition and Digestion of Infants, Arch. Pediat. **30**:740, 1912.

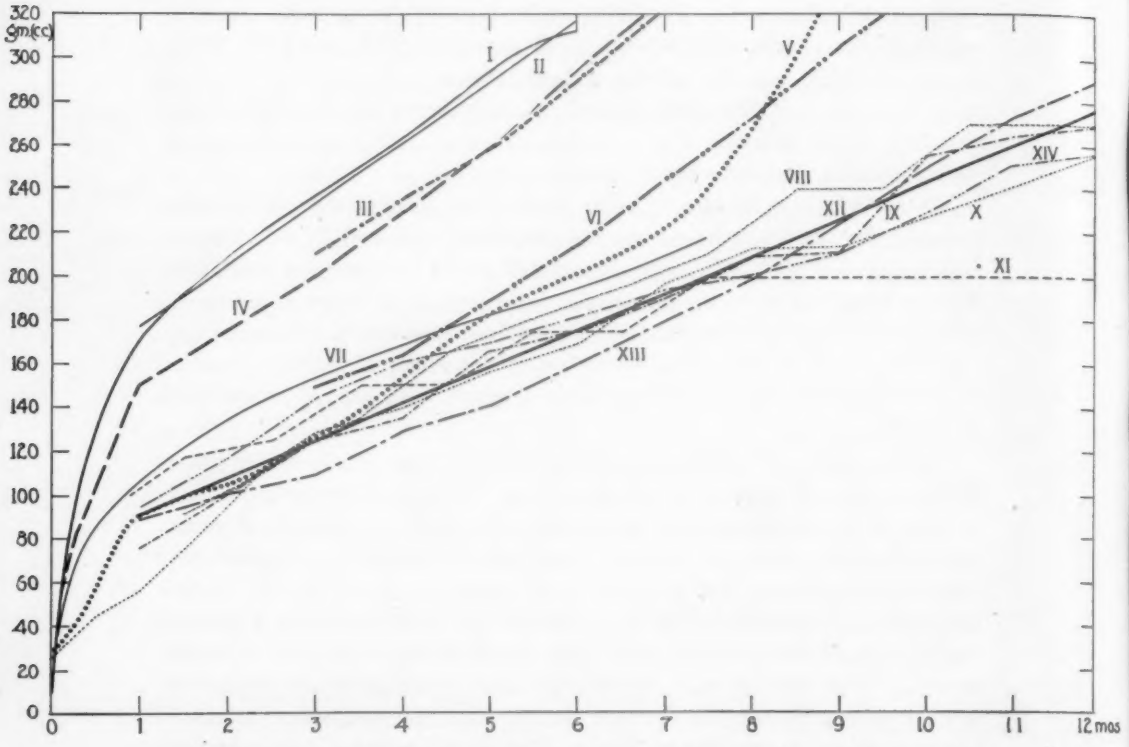

Fig. 11.—A series of curves illustrating the increase in gastric capacity in the first year as determined by a number of different methods, and also two curves based on empirical formula: 1. Curve of average maximum feeding per week in selected cases (corresponding to the upper curve in Figure 8); 2. Curve based on the formula $C = 150 + 7N$ where C is the gastric capacity in cubic centimeters or grams and N is the age in weeks. 3. Curve of capacity of excised systolic stomachs at a pressure of 30 cm. of water (Pfaundler's data). 4. Curve of capacity of excised diastolic stomachs at a pressure of 30 cm. of water (Pfaundler's data). 5. Curve of gastric capacity as determined from the data of all anatomic methods excepting Pfaundler's. 6. Curve of the capacity of the excised stomach at a pressure of 20 cm. of water (Pfaundler's data). 7. Curve of the average intake per single feeding in the given week in selected cases (corresponding to the lower curve in Figure 8 but extended over a somewhat longer period). 8. Curve of the average amount of a single feeding as determined by Ladd.[39] 9. Curve of the average amount of a single feeding as determined by Rotch.[39] 10. Curve of the average amount of a single feeding as determined by Holt. 11. Curve of the average amount of a single feeding as determined by Escherich.[40] 12. Curve based on the formula $C = 75 + 4N$ where C is the capacity in cubic centimeters or grams and N the age in weeks. 13. Curve of capacity of excised systolic stomachs at a water pressure of 15 cm. (Pfaundler's data). 14. Curve of the average amount of a single feeding as given in Smith's[41] feeding chart. The curve has been enlarged to the same scale as the other curves in this figure.

40. Escherich: (Quoted from Pfaundler, 19.)

41. Smith, C. H.: A Graphic Feeding Chart: A Method for Calculating Milk Percentages and Caloric Values, Arch. Pediat. **29**:827, 1912.

on Smith's feeding chart (XIV), and on Pfaundler's figures of anatomic capacity at 15 cm. water pressure, continue their former course until the end of the first year while the graph based on Escherich's[40] estimate of the average intake per single meal falls somewhat lower (Curve XI).

On the basis of this general graph several conclusions can be drawn as to the results obtained with the various methods of determining gastric capacity in the first year. These may be summarized as follows:

1. Most curves of gastric capacity, regardless of the method by which this capacity is determined, are of the same general type. They show an initial stage of rapid rise followed by a much longer stage in which the rise is slower and without important changes in rate. The initial stage of rapid rise extends from birth to the end of the third or fourth week. The second stage extends from the latter time to the end of the first year. The exceptions to this rule are the curve based upon Holt's observations in which the period of the initial rise is somewhat longer than usual, and the curve based on the average anatomic capacity as determined by all methods which rises very rapidly after the seventh month. The rapid rise of the latter curve is probably due to the inclusion in the material on which it is based of a number of pathologic and diastolic stomachs.

2. The curve of gastric capacity as determined from the maximum meal in a given week corresponds to a curve of the postmortem capacity of the stomach at a pressure at a little over 30 cm. of water. The capacity as determined by this method is from 50 to 75 per cent. greater than the capacity as determined by the majority of other methods.

3. For a period beginning shortly after birth and extending to the close of the fifth or sixth month, the curve of the average anatomic capacity as determined by all methods is in substantial agreement with the curves based on some of the more extensive collections of data on the amount of the average single feeding. While it is a little higher than some of these, it is lower than the curve based on the average single feeding in the eleven selected cases considered in this article.

4. All curves based on the average intake at a single meal fall between the curves of anatomic capacity at 15 cm. and at 20 cm. water pressure, for the period from 2 to 8 months. Thereafter they tend to fall below the curve of anatomic capacity at 15 cm. water pressure.

5. Since most of the curves of the increase in gastric capacity for the period between the end of the third or fourth week and the close of the first year tend to approach straight lines, it is possible to estab-

lish certain empirical formulas of a simple type which will represent them fairly well. Such formulas are based on a constant initial sum, with a regular weekly or monthly increment. A curve which, for the period under consideration, will pass through the middle of the group of curves representing the average intake per single meal, the average anatomic capacity for the first six months, and the curve based on Pfaundler's data on the anatomic capacity of the stomach at 15 cm. water pressure, is represented by the formula $C = 75 + 4N$, where C is the gastric capacity in grams or cubic centimeters and N is the age in weeks. A curve which will closely approach the curve of maximum meal per week is indicated by the formula $C = 150 + 7N$. This formula holds good from the fourth to the twenty-fourth week. A curve which will closely follow the curve based on the average single feeding in selected cases from the fourth week to the middle of the eighth month is represented by formula $C = 90 + 5N$.

I wish to express my thanks to Drs. J. P. Sedgwick and C. M. Jackson for valuable suggestions in connection with this study.

Additional references:

FAT METABOLISM OF INFANTS AND YOUNG CHILDREN

II. FAT IN THE STOOLS OF INFANTS FED ON MODIFICATIONS OF COW'S MILK *

L. EMMETT HOLT, M.D.

ANGELIA M. COURTNEY AND HELEN L. FALES

NEW YORK

In a previous article of a series of studies on the fat metabolism of infants and young children we have reported the results of the examination of stools of breast fed infants. In the present paper are presented the results of the study of a large number of stools of infants fed on cow's milk or various modifications of the same, with or without carbohydrate additions. The digestion of the larger number of the infants was quite normal; some were suffering from disturbances of digestion of varying degrees of severity.

The questions here considered are practically the same as those discussed in the study of the stools of breast fed infants, namely:

1. What is the variation in the per cent. of total fat and the distribution of fat in the stools of infants fed on cow's milk, under different conditions of digestion?

2. How is the fat per cent. and the distribution of fat in the stool affected by the fat intake?

3. What per cent. of fat is retained under different conditions of digestion and how is the retention affected by the amount of fat intake?

The material examined consisted of 128 specimens of feces from seventy-seven infants whose ages ranged from 2 to 18 months. Some of the older infants who were taking whole milk are included because the amount of solid food they were receiving in addition was not sufficient to put them in the class with other children of their age on mixed diet. The exact food in each case is given in the tables. The milk formulas are expressed as per cent. of fat, carbohydrate and protein in the order stated. All additions to the milk — sugars, flours, etc., have been included in the values as stated. Other additions to the diet — cereals, orange juice, olive or cod liver oil, etc. — are stated as such. The condition of the children with respect to digestion is considered in connection with the various tables.

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* From the Laboratories of the Rockefeller Institute for Medical Research and the Babies' Hospital.

The collected stools were dried on the waterbath to constant weight and ground to a powder. Analyses were made for total fat and its distribution as soap, free fatty acids and neutral fat. The findings numbered from 49 through 101 were obtained by the use of the method recently described by us,[1] and which was used to obtain the results in our previous paper on "Fat in the Stools of Breast Fed Infants."[2] The findings in the remaining cases, numbered from 102 through 176, were obtained by a modified Soxhlet extraction.[3] The separation of free fatty acids and neutral fat has not been included in this paper unless obtained by the titration method.

Since the soap content of the acid stools of breast fed infants is increased during the drying process, an investigation was made to determine whether a similar change occurs in the stools of children fed on cow's milk. Accordingly, a large composite specimen, representing normal or practically normal types of stools of artificially fed infants, was analyzed both in the moist state and after drying on the waterbath. It was found by this investigation that neither the total fat nor the distribution of fat was affected by drying. It is possible that acid diarrheal stools, like the acid stools of breast fed infants, might show a lower soap if analyzed moist than is present after drying.

The gross appearance of the stools is commonly used by pediatrists as their chief guide in infant feeding. Hence, the data presented have been classified according to the gross appearance of the stools and their water content.

Tables 1 to 9 are concerned with the fat per cent. of dried weight and the distribution of fat as soap, free fatty acids and neutral fat; Tables 10 to 18 consider the fat retention.

THE AMOUNT AND DISTRIBUTION OF THE FAT

Table 1 includes the findings on those stools which were hard, or dry and crumbly; that is, all the stools which might be regarded as constipated. Most of the infants could be classed as normal, healthy children; the rest, though under weight, were doing well at the time.

The fat per cent. of dried weight is quite uniform, averaging 36.0. There are only three values below 30, and only five above 40 per cent. The soap per cent. of total fat is very high, averaging 73.8. In thirteen instances the soap is over 70 per cent. of the fat in the stool. Of the other two constituents the fatty acids, averaging 17.6 per cent., exceed the neutral fat, which averages 9.0. In only two cases is this relationship reversed.

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1. Am. J. Dis. Child. **17**:38 (Jan.) 1919.
2. Am. J. Dis. Child. **17**:241 (Apr.) 1919.
3. Am. J. Dis. Child. **3**:1, (Jan.) 1912.

TABLE 1.—TOTAL FAT AND FAT DISTRIBUTION IN CONSTIPATED STOOLS

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
						Soap	Free Fatty Acids	Neutral Fat
77	F. J.	15	Whole milk	30.0	35.1	89.2	7.9	2.9
67	M. R.	6	2.4 8.3 2.5	23.4	37.3	80.7	9.8	9.5
60	F. N. 1	11	2.6 11.7 2.9 1 oz. orange juice	26.2	44.5	80.4	10.0	9.6
71	P. D. 2	7	2.4 8.2 3.0	22.6	38.6	79.0	17.9	3.1
49	G. H.	7.5	4.1 4.9 2.2 (top milk) 2 tsp. malt. & C. L. O.	48.3	48.1	78.0	9.5	12.5
171	R. M. 3	9	2.5 6.8 2.5	31.5	31.4	77.4		
138	E. R. 1	4	1.4 5.0 1.2	13.2	25.9	77.2		
70	P. D. 1	7	2.4 8.2 3.0	22.9	36.3	76.4	18.7	4.9
128	A. R. 5	8	2.4 6.6 2.8	21.6	30.8	74.8	7.3	17.9
89	M. O. 2	5.5	1.5 5.0 2.7 (evaporated milk)	11.7	36.7	74.5	17.9	7.6
93	A. T.	3.5	1.5 5.0 2.7 (evaporated milk)	9.5	15.7	74.1	18.6	7.3
72	A. K.	5.5	2.8 5.0 2.6	22.1	46.1	72.9	18.0	9.1
75	M. H.	8	3.0 5.0 2.8 1 tbsp. cereal	20.9	41.5	71.7	18.8	9.5
65	P. D. 3	7.5	2.3 9.2 2.8	24.0	34.2	69.5	27.0	3.5
52	J. S.	15	Whole milk, C.L.O.* 2 tbsp. cereal	30.5*	39.5	69.1	19.9	11.0
99	M. B. 2	13	Whole milk	17.0	34.3	68.1	21.4	10.5
61	E. C. 1	14	2.3 7.3 2.4 2 tbsp. cereal, 1 prunes, 1 spinach	25.5	21.8	65.3	21.2	13.5
90	W. D.	2.5	1.6 5.2 1.4 (dried milk)	11.3	50.9	63.5	24.2	12.3
69	M. L.	7	3.0 7.0 2.8 2 tbsp. cereal	23.0	34.5	59.9	31.2	8.9
Average				22.9	36.0	73.8	17.6	9.0

* Intake uncertain; cod liver oil indefinite.

Table 2 presents the results of analyses of the stools of the type generally considered normal. They were formed or semiformed, smooth and homogeneous. They were not hard or dry and showed no signs of mucus. All the infants were in good condition as to digestion and were gaining weight.

The fat per cent. of dried weight in this group averages the same as that in Table 1, and the range is practically identical. The fat per cent. in the stool of E. M., 82.6 per cent., is the highest value that has ever come under our observation. This child was brought to the hospital suffering from forcible vomiting. She was taking 6 ounces of cream (the top 3 ounces from each of 2 quart bottles of milk) with 18 ounces of water and dextrimaltose. This formula was thus high in fat and carbohydrate and low in protein and salts. The child was also receiving two tablespoonfuls of milk of magnesia daily. After the collection of the stools for analysis, the food was changed and the vomiting ceased. In spite of the extremely high per cent. of fat in the stool of this child, the stool was normal in appearance, and it contained a high per cent. of soap. The large amount of magnesia taken may possibly have influenced the soap formation.

TABLE 2.—TOTAL FAT AND FAT DISTRIBUTION IN STOOLS OF NORMAL CONSISTENCY

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
						Soap	Free Fatty Acids	Neutral Fat
			Fat Carb. Prot.					
62	J. M.	7	2.2 6.7 2.0	24.4	20.6	89.3	6.1	4.6
81	R. B.	15	Whole milk, 4 tbsp. cereal	31.1	56.7	89.0	5.1	5.9
58	J. I.	12	2.4 8.7 2.6 3 oz. orange juice	28.6	22.4	85.8	6.2	8.0
87	B. I.	3.5	1.2 5.3 1.5	14.6	21.3	85.7	8.5	5.8
172	F. P. 1	3	1.4 6.7 1.4	14.7	45.4	85.2		
84	N. K. 3	2	2.4 4.8 2.1	15.1	15.7	81.0	10.9	8.1
73	P. S. 1	8	2.1 6.6 2.0	22.0	25.7	80 8	9.7	9.5
91	M. O. 1	5.5	1.5 5.0 2.7 (evaporated milk)	11.5	39.0	80.0	12.1	7.9
53	B. B.	3	3.0 7.0 1.8 (top milk)	27.8	50.2	79.2	14.6	6.2
76	P. S. 2	8	2.4 6.5 2.3 1 oz. orange juice	18.8	19.7	79.0	10.5	10.5
158	H. B.	13	Whole milk, 2 pc. bread, 2 tbsp. cereal	34.7	36.0	79.0	15.0	6 0
124	W. J. 1	5	2.2 2.9 1.7	23.3	38.7	78.9		
68	M. M.	11	2.1 8.0 2.5 2 oz. potato, 1 tsp. butter	23.3	21.4	77.6	9.9	12.5
55	J. D.	7	2.7 8.8 2.7	30.1	30.6	72.9	15.6	11.5
54	R. C.	8.5	2.5 6.0 2.4 4 tbsp. cereal, 1 veg. 1 oz. orange juice	32.8	28.2	72.8	18.2	9.0
57	M. S. 2	8	2.7 6.0 2.8 1 tbsp. cereal, 1 tsp. veg., 1 oz. beef juice, 2 oz. orange	29.4	34.7	72.2	18.6	9.2
168	W. J. 10	7	0.7 2.3 2.2	7.9	18.9	72.2		
96	R. L. 1	12	Whole milk	30.0	32.6	72.2	13.3	14.5
78	M. S. 1	4	1.7 5.0 1.8	16.7	42.9	72.0	23.0	5.0
140	R. M. 2	4.5	1.8 5.0 2.1	18.9	39.0	71.8		
50	B. P.	10	4.1 4.9 2.0 (top milk)	36.5	36.4	71.2	18.9	9.9
110	D. L.	8	2.2 7.3 2.0	24.1	36.0	70.1		
88	G. B.	3	1.5 6.5 3.0 (evaporated milk)	12.7	33.3	68.5	19.6	11.9
105	R. S. 1	7	1.8 6.2 2.1 12 c.c. olive oil	33.8	34.1	63.5		
80	R. L. 3	12	Whole milk, 1 pc. bread, 1 tbsp. cereal	30.5	51.0	62.6	27.8	9.6
51	E. M. 1	2	5.0 5.0 0.9 (top milk)	36.0*	82.6	61.2	31.3	7.5
163	J. D.	5	1.8 5.0 2.1	18.9	46.5	59.1		
100	M. B. 1	13	Whole milk	17.0	38.1	56.4	24.7	18 9
122	V. D.	9	1.6 5.4 1.6 6 gm. olive oil	22.3	38.9	52.2		
79	R. L. 2	12.5	Whole milk, 1 pc. bread, 1 tbsp. cereal	30.5	48.6	43.7	42.7	13 6
117	W. H. 2	12	1.8 5.6 1.6 12 c.c. C. L. O.	25.4	37.3			
	Average			24.0	36.2	72.8	16.5	9.4

* Intake approximate; no sample of top milk available for examination.

The distribution of fat shown in Table 2 is also almost identical with that in Table 1. The soap averages 72.8 per cent of the total fat. There are three values lower than any found in Table 1, but Table 2 contains a proportionally larger number of high values. The averages for free fatty acids and neutral fat are practically the same in the two groups. Hence, as to total fat and distribution of fat, no distinction can be made between the stools of normal appearance and the hard, constipated type. The chief difference appears to be a

matter of water content. This view is confirmed by a comparison of the protein and ash content of the two types of stools. The average protein per cent. of dried weight of eight constipated stools was found to be 26.5, the average of eight normal stools 25.4. The average ash per cent. of dried weight of fifteen hard stools was 23.7, that of twenty normal stools was 24.1 per cent. of the dried weight. These averages were based on analyses made on the material considered in Tables 1 and 2. The most striking point brought out in Table 2 is that so many normal stools of healthy infants contain so high a proportion of their fat in the form of soap.

In Table 2 are presented the findings on a group of stools which were similar in appearance to the normal, but softer, for the most part not formed, but smooth and homogeneous and showing little or no mucus. None were included in this group that contained more than 75 gm. of water in the twenty-four hours' stool and none in which the dried weight was less than 14 per cent. of the moist weight. All but three of the infants were in good condition and gaining weight, although several of them had previously suffered from digestive disturbances.

TABLE 3.—FAT CONTENT AND DISTRIBUTION IN STOOLS SOFTER THAN NORMAL

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
86	J. M.	4	1.6 5.2 1.4 (dried milk)	13.4	34.5	80.4	11.0	8.6
83	A. P.	6	1.8 5.0 2.2	15.1	18.7	75.9	14.3	9.8
63	F. N. 2	11	2.4 11.6 2.7 1 oz. orange juice	24.1	41.1	72.4	19.6	8.0
97	B. W. 1	15	Whole milk, half egg, 1 pc. zwieback	27.6	39.2	72.1	16.2	11.7
56	J. K. 1*	15	4.2 7.7 2.7 (top milk)	29.7	29.6	71.3	17.3	11.4
101	J. K. 2	16	Whole milk, 1 oz. beef juice, 1 tbsp. cereal, 1 fruit	16.5	12.8	68.7	19.6	11.7
94	E. W.	5	0.5 10.0 2.1 (malted milk)	3.4	16.4	68.2	16.7	15.1
74	E. C. 2	15	1.8 3.9 2.0 2 tbsp. cereal, 1 prunes	21.1	26.2	64.9	30.3	4.8
153	R. S. 3	8	2.4 8.2 2.3	27.7	25.6	62.9		
173	I. P. 1	4	1.1 10.5 1.6 8 gm. olive oil	20.2	39.0	58.1		
114	R. S. 2	8	2.4 8.2 2.3	27.7	29.0	57.9		
137	R. D. 1†	7.5	1.9 6.5 1.7	19.7	45.0	54.8		
103	W. J. 6	6	2.7 2.7 2.4	31.5	46.3	49.3		
145	R. M. 1	3.5	1.6 5.0 1.4	18.5	53.2	38.3		
66	P. S. 3	10	2.5 10.6 2.6 15 c.c. orange juice	23.7	10.2	35.9	34.4	29.7
64	L. R.‡	12	1.7 5.9 2.4 12 c.c. cod liver oil	24.6	43.8	26.3	65.8	7.9
	Average			21.5	31.9	59.8	24.5	11.9

* Marked case of malnutrition.
† Gaining, but had a nasal infection with K. L. bacillus; subsequently very ill.
‡ Very delicate; rickets and marasmus.

Table 3 shows some marked variations from 1 and 2. The total fat per cent. of dried weight is lower; the average being 31.8 per cent., and the range 10.2 to 46.3. The fat distribution shows an average for soap of 59.8 per cent., which is considerably lower than in the normal and the constipated stools; consequently, the fatty acids and neutral fat are higher, although they bear the same relation to each other as in the previous tables. The soap, however, still represents considerably more than half the fat of the stool.

Table 4 includes the findings on a number of stools which were not normal in appearance, but were not sufficiently loose to be classed as diarrheal. None were smooth and homogeneous, and all showed fat curds or mucus, or both, in considerable amount. The digestion of the children whose stools are considered in this table was not quite normal, and a large proportion of the infants subsequently developed diarrhea.

TABLE 4.—FAT CONTENT AND DISTRIBUTION IN STOOLS WHICH WERE NOT HOMOGENEOUS

No.	Case	Age, Months	Feeding			Intake of Fat, Gm. Daily	Analyses of Stools			
							Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat	Carb.	Prot.			Soap	Free Fatty Acids	Neutral Fat
59	L. H.*	9	2.6	6.0	1.8					
			2.3	5.2	2.0	19.8	27.5	77.8	17.5	4.7
98	A. K.	18	Whole milk, 4 tbsp. cereal, 1 tbsp. veg., 15 c.c. orange			26.4	41.4	76.2	14.4	9.4
92	L. B.*	3.5	1.7	9.7	1.4	12.5	45.2	67.3	17.8	14.9
82	P. L.*	4	1.8	5.2	1.6	15.7	26.1	64.7	27.7	7.6
			(dried milk)							
85	C. M.	2	1.6	5.0	1.7	14.4	33.4	64.4	23.7	11.9
155	D. W. 1†	5	1.8	5.0	1.6	17.2	48.8	55.2	13.1	31.7
154	W. H. 1*	12	1.8	5.6	1.5	17.4	14.8	54.2		
126	W. H. 4	14	2.4	6.2	2.3	35.8	38.6	50.5		
			1 tbsp. cereal, 12 c.c. C. L. O.							
104	C. R.	4	0.0	6.5	1.6	0.0	11.8	44.1		
174	B. B.*	4	1.4	6.7	1.4	14.7	54.7	41.2		
170	R. B. 2*	3	1.4	1.6	1.2	13.2	33.9	30.2		
119	W. H. 5	14	2.4	6.1	2.3	25.2	29.0	29.7		
			1 tbsp. cereal							
160	R. C. 1‡	5	0.9	5.4	2.0	6.7	18.8	23.4		
113	J. S. 1	7.5	1.2	5.0	3.2	26.6	13.1	16.8		
			14 c.c. olive oil							
169	R. C. 2‡	5	1.2	5.9	1.4	9.2	50.3	16.2		
166	A. A.*	7	1.4	6.9	2.0	11.4	35.6	1.6	21.1	77.3
Average						16.1	32.7	44.6	19.3	22.5

* Child delicate; digestion not good.
† Child not in good condition; tetany; rickets; developed diarrhea.
‡ Child in bad condition; edema; idiot.

The total fat per cent. of dried weight of the stools in this group is not greatly different in average or in range from that of the previous tables. In this group the wide range may be explained by the fact

that some of the stools contained considerable mucus, which diminishes the fat per cent., while others contained fat curds, which increase the per cent. of total fat. The most notable feature of this table is the extremely wide range in per cent. of soap fat. This is not surprising since the stools were classified together only because they contained curds and mucus and were not homogeneous. The soap fat forms on the average 44.6 per cent. of the total fat.

The group of stools, the analyses of which are shown in Table 5, were distinctly loose, containing from 70 to 100 gm. of water in the daily stool, which is more than twice the amount usually contained in normal stools. The infants observed were convalescent from digestive disturbance and were in fair condition.

TABLE 5.—FAT CONTENT AND DISTRIBUTION IN LOOSE STOOLS

No.	Case	Age, Months	Feeding			Intake of Fat, Gm. Daily	Analyses of Stools			
							Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat	Carb.	Prot.			Soap	Free Fatty Acids	Neutral Fat
129	J. G. 4	8	2.8	6.5	2.5	32.3	38.1	54.0		
148	W. J. 3	6	1.6	4.7	2.1	18.3	31.7	50.2		
112	W. J. 5	7	2.3	2.6	2.3	27.0	47.8	40.8		
125	W. G. 2	7	2.1	4.9	2.6	22.5	29.1	35.1		
107	F. H. 11	13	2.4	6.8	2.5	29.9	18.1	32.6		
151	W. G. 1	7	1.7	4.8	2.4	17.9	20.2	30.8		
144	V. R. 2	3	1.6	5.0	1.4	18.7	24.0	30.4		
143	F. S.	6	1.7	6.0	2.1	18.7	36.1	28.3	16.6	55.1
108	W. G. 3	7.5	2.3	4.7	2.6	29.8	32.3	24.3		
			6 c.c. olive oil							
116	W. G. 4	7.5	1.7	4.5	2.2	25.5	41.2	17.6		
			8 c.c. olive oil							
115	F. H. 9	13	2.1	5.7	2.5	26.2	17.8	14.4		
159	D. F. 3	4	1.2	5.2	1.5	12.9	25.4	8.2		
	Average					23.3	30.2	30.6	(16.6)	(55.1)

The average proportion of the dried weight which is fat as shown in this table is similar to that of the two preceding tables, but the range is narrower. With the increase in the proportion of water in the stools a marked reduction of the soap per cent. of total fat is observed. In this group it averages 30.6 per cent. and there are only two values over 50 per cent.

The diarrheal stools are arranged in two groups according to the amount of water in the daily stools. Those which contained between 100 and 200 gm. of water daily are grouped together and are designated simply as diarrheal, and the findings are given in Table 6. The stools which contained more than 200 gm. of water daily are classed as severely diarrheal and the analyses are shown in Table 7. Most of the children were very ill and the digestion of all was markedly abnormal.

TABLE 6.—Fat Content and Distribution in Diarrheal Stools

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
102	J. G. 3	7.5	2.2 9.0 2.2	25.4	27.3	47.9		
147	W. H. 3	14	2.4 6.1 2.3 1 tbsp. cereal	18.4	22.3	27.4		
146	J. G. 1	7	2.4 5.6 2.2 12 c.c. olive oil	39.7	49.9	24.6		
149	W. J. 2	5	1.7 6.3 1.7	18.1	36.2	21.1		
136	F. H. 2	10	2.7 3.8 2.2	33.6	29.5	20.3		
167	R. B. 3	3.5	1.1 3.2 1.2	9.2	34.1	20.8		
150	J. G. 2	7	2.4 5.6 2.2	30.7	33.8	18.7		
130	R. B. 1	3	1.4 5.5 1.2	13.2	16.6	16.3		
127	D. W. 2	5	1.8 5.8 1.6 6 c.c. cod liver oil	22.2	48.9	15.3	23.2	61.5
161	I. P. 2	4.5	1.4 12.0 1.8 8 c.c. olive oil	24.4	25.4	15.1		
162	D. F. 1	3.5	1.5 5.9 1.5	15.8	24.0	14.7		
165	P. V.	5.5	1.4 5.4 1.7	15.0	32.2	13.8		
139	J. D.	5	1.6 5.8 1.6 3.4 c.c. cod liver oil	17.0	48.0	13.6	24.0	62.4
134	D. F. 2	4	1.3 5.2 1.5	14.0	26.2	12.1		
135	F. H. 4	11	1.6 4.7 3.0	20.0	14.2	11.8		
142	W. J. 6	7	1.0 2.9 2.4	12.1	31.8	11.1		
175	I. G.	2.5	1.8 4.8 2.3 (evaporated milk)	14.7	61.4	7.4	36.8	55.8
118	A. H.	11	2.0 5.3 1.8	25.2	45.9	4.7		
152	M. R.	4	1.3 6.9 2.2	5.4	41.5	3.5	50.7	45.8
133	F. H. 10	13	1.6 6.7 2.5	20.6	16.4	1.6		
106	V. C. 3	5	1.8 2.8 2.1 12 c.c. cod liver oil	30.2	54.2	0.0	17.5	82.5
111	E. R. 2	10	1.8 6.3 2.2 4 tbsp. cereal, 12 c.c. cod liver oil	27.1	31.6	0.0		
123	E. R. 3	10.5	1.4 6.3 2.2 4 tbsp. cereal, 12 c.c. cod liver oil	23.4	39.4	0.0		
131	E. R. 1	10	2.0 8.7 2.7 4 tbsp. cereal	16.8	44.1	0.0		
164	B. S. 2	12	1.9 6.8 2.1 1 tbsp. cereal	15.5	29.5	0.0		
141	F. H. 3	11	0.0 6.0 3.5	0.0	3.9	0.0		
	Average			19.5	33.4	12.4	30.4	61.6

TABLE 7.—Fat Content and Distribution in Severely Diarrheal Stools

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
157	E. R. 2	4.5	1.3 5.9 1.2	11.8	30.2	22.8		
132	F. H. 1	10	2.6 4.5 2.4	32.4	34.7	17.0		
95	J. B.	4	1.3 3.5 1.6 (evaporated milk)	6.4	46.1	9.8	43.2	37.0
156	W. S. 1	4	1.6 5.8 1.5	17.0	36.6	8.6		
109	S. J.	9	2.7 5.3 2.5 (evaporated milk)	29.1	57.5	8.9	36.3	54.8
121	V. C. 2	5	1.8 2.9 2.1 6 c.c. cod liver oil	23.6	49.5	3.3	30.3	46.4
120	V. C. 1	5	1.8 5.6 2.0 6 c.c. cod liver oil	23.6	43.6	0.0	32.7	67.3
176	B. S. 3	13	1.8 5.9 1.9 one-half tbsp. cereal	11.6	27.0	0.0		
	Average			19.4	40.7	8.8	38.1	56.4

In Table 6 the total fat, averaging 33.4 per cent. of the dried weight, shows no significant difference from that of the two preceding groups. Table 7, however, shows a marked increase in per cent. of total fat, averaging 40.2, the highest of all the groups. The per cent. of total fat which is soap shows a striking decrease in both these groups, averaging only 12.4 in Table 6 and 8.8 in Table 7. In Table 6 there is only one soap value over 27 per cent., while in the group of severe diarrhea, Table 7, there are only two instances with a soap per cent. above 10. Although the number of cases in which a separation of the neutral fat and the free fatty acids was obtained was small, the high per cent. of neutral fat in all shows that a much lessened degree of fat splitting is one of the accompaniments of diarrhea.

For comparison, the averages of the seven previous tables have been brought together in Table 8.

TABLE 8.—SUMMARY OF AVERAGES OF TABLES 1 TO 7

Table	Type of Stools	Number of Observations	Intake of Fat, Gm. Daily	Analyses of Stools			
				Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
					Soap	Free Fatty Acids	Neutral Fat
1	Constipated.....	19	22.9	36.0	73.8	17.6	9.0
2	Normal.....	31	24.0	36.2	72.8	16.5	9.4
3	Softer than normal.	16	21.5	31.9	59.8	24.5	11.9
4	Not homogeneous...	16	16.1	32.7	44.6	19.3	22.5
5	Loose.....	12	23.3	30.2	30.6	16.6*	55.1*
6	Diarrheal.....	26	19.5	33.4	12.4	30.4	61.6
7	Severely diarrheal...	8	19.4	40.7	8.8	38.1	56.4

* Only one case.

This table gives an answer to the first question stated at the beginning of this article, namely, What is the variation under different conditions of digestion in the per cent. of total fat and the distribution of fat in the stools of artificially fed infants?

The average values for the fat per cent. of dried weight in the various groups range from 30 to 40 per cent. The constipated stools have the same average per cent. as the normal. The fat average is highest in the group of severe diarrhea. In the groups of stools intermediate between the normal and those of severe diarrhea the total fat per cent. of dried weight is lower than in the normal. This may be due to the presence in these types of stools of more or less mucus. Undoubtedly the stools in severe diarrhea also contain much mucus, but in this condition the absorption of fat is so very poor that there is an extremely large amount of fat in the stool and a consequently high per cent. of the dried weight in spite of the presence of much mucus.

The distribution of fat shows wide variation according to the type of the stool. The stools which were normal and nearly normal in appearance show very high average values for soap. It is only when the stools show in their gross appearance evidence of digestive disturbance that the average values for soap drop below 50 per cent. of the total fat. In diarrheal stools the soap forms a very small proportion of the total fat. The fatty acids form the next larger proportion of the total fat in good stools, the lower neutral fat indicating excellent splitting of the ingested fat. In the diarrheal stool the proportion of neutral fat is greatly increased, forming on the average more than half the total fat.

Table 9 shows for comparison the average analyses of the stools of nursing infants and of infants taking cow's milk modifications. It gives average analyses of the normal stools and also the averages of the analyses of all the stools not diarrheal. All the children, the analyses of whose stools are included in the second average, were in fairly good condition as to digestion, most of them in excellent condition.

TABLE 9.—Comparison of Analyses of Stools of Infants Taking Cow's Milk and Those Taking Breast Milk

Food	Type of Stool	Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Soap	Free Fatty Acids	Neutral Fat
Cow's milk.....	Normal (Table 2).....	36.2	72.8	16.5	9.4
Breast milk.....	Normal (Table 1)*.....	42.1	57.8	26.3	15.9
Cow's milk.....	Average† (Tables 1 to 5).....	34.1	60.5	18.6‡	12.1‡
Breast milk.....	Average† (Tables 1 to 3)*.....	34.5	43.1	36.7	20.2

* Preceding paper. (Fat in the Stools of Breast Fed Infants.)
† Average of analyses of all types of stools except diarrheal. All the children were in fairly good condition as to digestion, most of them in excellent condition.
‡ Since the separation of free fatty acids and neutral fat was not obtained on all the stools, the average of soap, free fatty acids and neutral fat do not total to 100 per cent.

The normal stools of nursing infants show a higher average fat per cent. of dried weight, 42.1, than do the stools of infants fed on modifications of cow's milk, 36.2. But in the average which includes all the various types of stools exclusive of diarrheal, the fat per cent. of dried weight is exactly the same with both cow's milk and breast milk feeding. The soap per cent. of total fat is much higher in the stools of infants taking cow's milk than in those of infants taking breast milk, both in the case of normal stools and that of various types whose analyses were averaged together. This difference would have been even greater if the determinations had been made on the moist stools, since a lower soap value is found in the stools of nursing infants when examined moist than is found in the dried stool, while no such difference is found in the stools of infants taking cow's milk.

The neutral fat is distinctly higher in the stools of breast fed infants. The values for neutral fat need no correction for purposes of comparison, since the amount of neutral fat is not changed by the process of drying. From the foregoing facts the inference would seem to be warranted that in artificial feeding the aim should be to obtain a stool with a high proportion of soap fat rather than one in which the soap is lower, as it is in the stools of nursing infants.

The amount of daily fat intake has been incorporated in Tables 1 to 7. A study of these figures fails to reveal any definite relation between the fat intake and the per cent. of total fat or its distribution in the stool. The intake varied in the cases studied from 0 to 48.3 gm., the average intake for the various groups ranging from 16 to 24 gm. A large number of the cases with high fat intake appear in Tables 1 and 2. The per cent. of fat in the formula seems to bear no definite relation either to the per cent. of fat in the stool or its distribution.

RETENTION OF FAT

In about three fourths of the cases considered in the preceding tables, the stools were collected for a definite period, so that the actual and percentage retention of the fat intake was obtained. These values are also arranged according to the gross appearance and water content of the stool.

The first group, Table 10, includes the findings on those cases in which the stools were constipated.

TABLE 10.—RETENTION OF FAT WHEN STOOLS WERE CONSTIPATED

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
49	G. H.	48.3	2.98	45.3	93.8
171	R. M. 3	31.5	3.12	28.4	90.2
77	F. J.	30.0	1.75	28.3	94.2
60	F. N. 1	26.2	4.12	22.1	84.3
61	E. C. 1	25.5	1.71	23.8	93.3
65	P. D. 3	24.0	2.95	21.1	87.7
67	M. R.	23.4	2.79	20.6	88.0
70	P. D. 1	22.9	2.21	20.7	90.3
71	P. D. 2	22.6	3.34	19.3	85.2
72	A. K.	22.1	3.04	19.1	86.2
128	A. R. 5	21.6	2.12	19.5	90.1
	Average.....	27.1	2.74	24.4	89.9

The per cent. of the fat intake retained ranges from 84 to 94, with an average of nearly 90. The largest intake in all the cases studied was that of G. H. (No. 49). This child retained 93.8 per cent. of the unusually large intake of 48.3 gm., having an actual retention of 45.3 gm. In the case of F. N. (No. 60), who had the largest loss of fat in the stool, the food contained an unusually high proportion of carbohydrate.

Table 11 presents the figures for fat retention in the cases in which the stools were of normal consistency.

TABLE 11.—RETENTION OF FAT WHEN THE STOOLS WERE NORMAL IN APPEARANCE

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
50	B. P.	36.5	2.91	33.6	92.1
158	H. B.	34.7	4.93	29.8	85.8
105	R. S. 1	33.8	2.37	31.4	93.1
54	R. C.	32.8	2.70	30.1	91.8
81	R. B.	31.0	3.91	27.1	87.4
55	J. D.	30.1	1.35	28.8	95.6
96	R. L. 1	30.0	4.07	25.9	86.4
57	M. S. 2	29.4	3.36	26.0	88.6
58	J. I.	28.6	1.30	27.3	95.4
117	W. H. 2	25.4	2.24	23.2	91.2
62	J. M.	24.4	1.14	23.3	95.3
110	D. L.	24.1	3.41	20.7	86.0
68	M. M.	23.3	1.24	22.1	94.7
122	V. D.	22.3	2.76	19.5	87.6
73	P. S. 1	22.0	0.73	21.3	96.7
140	R. M. 2	18.9	2.59	16.3	86.2
76	P. S. 2	18.8	0.62	18.2	96.7
87	B. L.	14.6	0.38	14.2	97.4
	Average.....	26.7	2.33	24.4	91.3

The range in retention is from 85.8 to 97.4 per cent. of the fat intake, the average being 91.6. Three cases (Nos. 81, 96, 158) show a high loss of fat, comparable with that of No. 60 in the preceding table. These three infants were all fed on whole milk, two of them having cereal additions. A comparison of Tables 10 and 11 shows that there is no significant difference in the average daily loss of fat whether the stools are hard and constipated or of normal consistency. In Table 11, representing normal stools, there are seven instances in which there is a smaller daily fat loss than the lowest reported in Table 10 in which the stools considered were constipated.

TABLE 12.—RETENTION OF FAT WHEN THE STOOLS WERE SOFTER THAN NORMAL

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
103	W. J. 4	31.5	6.75	24.8	78.6
56	J. K. 1	29.7	2.48	27.2	91.7
114	R. S. 2	27.7	2.49	25.2	91.0
153	R. S. 3	27.7	3.22	24.5	88.5
97	B. W. 1	27.6	2.54	25.1	90.8
64	L. R.	24.6	4.60	20.0	81.2
63	F. N. 2	24.1	5.09	19.0	78.8
66	P. S. 3	23.7	0.85	22.9	96.3
74	E. C. 2	21.1	2.71	18.4	87.2
173	I. P. 1	20.2	2.10	18.1	89.6
145	R. M. 1	18.5	2.81	15.7	84.8
101	J. K. 2	16.5	0.66	15.8	96.0
83	A. P.	15.1	0.65	14.6	95.7
86	J. M.	13.4	2.08	11.3	84.6
	Average.....	23.0	2.79	20.2	87.9
94	E. W.	3.4	1.09	2.3	68.3

In Table 12 is shown the retention of fat when the stools were nearly normal but contained a larger proportion of water.

In this table are seen several values for percentage retention of fat lower than any found in the two preceding tables, and the average, 87.9 per cent., is somewhat lower. A very high fat excretion is shown in three instances (Nos. 63, 64, 103); in only one of them was the intake high. Three others show very small fat excretion, but in two of them the intake was also low.

In calculating the averages in this and following tables we have not included any cases in which the intake was less than 10 gm. It is noteworthy that when the intake was below this amount the per cent. of retention in our cases was always very low.

Table 13 shows the fat retention in a group of cases which are classed together because the stools were not smooth or homogeneous, but contained fat curds or mucus, or both.

TABLE 13.—RETENTION OF FAT WHEN THE STOOLS WERE NOT HOMOGENEOUS

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
126	W. H. 4	35.8	3.35	32.5	90.7
113	J. S. 1	26.6	1.53	25.1	94.3
98	A. K.	26.4	1.61	24.8	93.9
119	W. H. 5	25.2	2.64	22.6	89.6
59	L. H.	19.8	0.69	19.1	96.5
154	W. H. 1	17.4	0.91	16.5	94.8
155	D. W. 1	17.2	3.73	13.5	78.3
82	P. L.	15.7	1.73	14.0	89.0
85	C. M.	14.4	1.64	12.8	88.8
170	R. B. 2	13.2	3.52	9.7	73.2
92	L. B.	12.5	2.06	10.4	83.5
166	A. A.	11.4	2.46	8.9	78.2
	Average.....	19.6	2.16	17.5	89.1
169	R. C. 2	9.2	3.16	6.0	65.6
160	R. C. 1	6.7	1.29	5.4	80.7
104	C. R.	0.0	0.33	....	Neg.

In this group the range of retention is wider than in the preceding, being from 73.2 to 96.5 per cent. of the intake, with an average of 89.1. There is here no essential variation from the normal either in average daily fat excretion or average per cent. of retention. The fat loss is slightly lower than that shown in the normal group; but this may be due to the lower intake.

The next group, presented in Table 14, shows the fat retention when the stools were loose.

The average per cent. of the intake retained in this group is 83.9, the range being from 71.9 to 92.8. The fat excretion several times reaches a high figure and the average is distinctly higher than in any of the preceding groups. None of the infants, however, were in a serious condition.

TABLE 14.—Retention of Fat When the Stools Were Loose

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
129	J. G. 4	32.3	4.48	27.8	86.2
107	F. H. 11	29.9	2.15	27.8	92.8
108	W. G. 3	29.8	4.32	25.5	85.5
112	W. J. 5	27.0	7.57	19.4	71.9
115	F. H. 9	26.2	2.29	23.9	91.2
116	W. G. 4	25.5	6.10	19.4	76.1
125	W. G. 2	22.5	2.85	19.7	87.3
144	V. R. 2	18.7	1.88	16.8	90.0
143	F. S.	18.7	4.20	14.5	77.6
148	W. J. 3	18.3	4.01	14.3	78.1
151	W. G. 1	17.9	2.04	15.9	88.6
159	D. F. 3	12.9	2.93	10.0	77.3
	Average.....	23.3	3.74	19.6	83.9

In Table 15 are grouped the cases in which the daily stools contained between 100 and 200 gm. of water; that is, cases which would be classed as moderate diarrhea.

TABLE 15.—Retention of Fat with Diarrhea

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
146	J. G. 1	39.7	7.83	31.9	80.3
136	F. H. 2	33.6	4.61	29.0	86.3
150	J. G. 2	30.7	4.77	25.9	84.5
106	V. C. 3	30.2	6.73	23.5	77.7
111	E. R. 2	27.1	3.76	23.3	86.2
102	J. G. 3	25.4	3.98	21.4	84.3
118	A. H.	25.2	4.23	21.0	83.2
161	I. P. 2	24.4	2.99	21.4	87.8
123	E. R. 3	23.4	4.97	18.4	78.7
127	D. W. 2	22.2	5.38	16.8	75.7
133	F. H. 10	20.6	2.06	18.5	89.9
135	F. H. 4	20.0	1.77	18.2	91.1
147	W. H. 3	18.4	2.10	16.3	88.6
139	J. D.	17.0	6.01	11.0	64.7
131	E. R. 1	16.8	3.35	13.5	80.1
162	D. F. 1	15.8	3.07	12.7	80.5
164	B. S. 2	15.5	3.07	12.4	80.2
165	P. V.	15.0	4.42	10.6	70.6
175	I. G.	14.7	11.62	3.1	20.8
134	D. F. 2	14.0	3.23	10.8	77.0
130	R. B. 1	13.2	2.70	10.5	79.8
142	W. J. 6	12.1	5.77	6.3	52.3
	Average.....	21.6	4.47	17.1	79.3
152	M. R.	5.4	3.61	1.8	33.3
141	F. H. 3	0.0	0.43	....	Neg.

A decided increase in the fat loss and corresponding decrease in fat retention appears. The fat retention averages 79.3. The average daily fat excretion is somewhat higher than in the preceding groups, ranging from 1.77 to 11.62 gm. The child I. G. (No. 175), who lost 11.62 gm. of fat in his daily stool, was fed on evaporated milk cooked with a considerable addition of starch. His stools were very large and showed fermentation; the appearance, however, was not that of a diarrheal stool, but the water content, 172 gm., and the total solids, 18.93 gm., were very high.

Table 16 shows the fat retention in the cases of severe diarrhea; that is, those in which the stools contained over 200 gm. of water daily.

TABLE 16.—RETENTION OF FAT WITH SEVERE DIARRHEA

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
132	F. H. 1	32.4	6.96	25.4	78.6
109	S. J.	29.1	14.54	14.6	50.0
120	V. C. 1	23.6	5.77	17.8	75.7
121	V. C. 2	23.6	10.38	13.2	56.1
156	W. S. 1	17.0	8.61	8.4	49.4
157	E. R. 2	11.8	5.56	6.2	53.0
176	B. S. 3	11.6	10.08	1.5	12.9
	Average.....	21.3	8.84	12.5	58.5
95	J. B.	6.4	12.58*		

* Child recently changed from higher fat intake.

This table illustrates strikingly the very great loss of fat which occurs in severe diarrheas. The smallest daily loss is over 5 gm., and the average is 8.8 gm. The retention ranges from 12.9 to 78.6 per cent. of the intake, the average being 58.5 per cent. The child, S. J. (No. 109), showed a condition similar to that of I. G. (No. 175) of the preceding table. The fat lost in the stools in this case was the greatest amount found in our entire series, being 14.54 gm. daily. The food in this case was similar to that of I. G., that is, evaporated milk with cooked starch.

The significance of the findings reported in Tables 10 to 16 is brought out more clearly if the averages of the different tables are considered together. These are given in Table 17.

TABLE 17.—SUMMARY OF AVERAGE FAT RETENTION

Table	Type of Stools	No. of Obser-vations	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
10	Constipated.....	11	27.1	2.74	24.4	89.9
11	Normal.....	18	26.7	2.33	24.4	91.3
12	Softer than normal.....	14	23.0	2.79	20.2	87.9
13	Not homogeneous.....	12	19.6	2.16	17.5	89.1
14	Loose.....	12	23.3	3.74	19.6	83.9
15	Diarrheal.....	22	21.6	4.47	17.1	79.3
16	Severely diarrheal.....	7	21.3	8.84	12.5	58.5

We have already stated that the groups with hard and with normal stools show no essential difference in fat retention. These groups, with the highest average intake, show the highest average per cent. of retention. In fact, in the first four groups the differences in the amount of fat excreted and the per cent. of fat retained are insignificant. It is not until the stools become loose that the fat excretion becomes considerably increased and the retention correspondingly

diminished. A comparative study of the last three groups shows strikingly the effect of an increase in the amount of water in the stools. The average daily fat excretion in loose stools is at least a gram more than that of any of the four preceding groups. In the diarrheal stools the average daily fat loss is much greater, nearly twice that shown in normal stools, and in severe diarrhea it is nearly four times the normal.

Table 18 shows the fat retention of infants fed on cow's milk in comparison with that of breast fed infants. In order to obtain values comparable with those obtained for the breast fed infants in good condition, the figures in Table 10 through 14 have been averaged. This gives the average fat loss and retention of all the infants fed on cow's milk modifications whose stools were not diarrheal.

TABLE 18.—Comparison of Fat Retention of Infants Taking Cow's Milk and Those Taking Breast Milk

Food	Type of Stools	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
Cow's milk.....	Average* (Tables 10 to 14)	24.2	2.72	21.4	88.6
Breast milk.....	Average* (Table 8)†.....	28.3	1.15	27.2	95.8

* Average of findings when the stools were of all types except diarrhea. All the children were in fairly good condition as to digestion, most of them in excellent condition.
† Preceding paper. (Fat in the Stools of Breast Fed Infants.)

The fat retention of the infants taking cow's milk averages 88.6 per cent. of the intake; of those taking breast milk it averages 95.8 per cent. of the intake. The daily loss of fat by infants fed on cow's milk is over twice as great as that lost by those taking breast milk, even though the actual amount of intake is somewhat less.

SUMMARY

1. The material presented in this article comprises the results of analysis of 128 stools of seventy-seven infants whose ages ranged from 2 to 18 months, fed on modifications of cow's milk.

2. The average fat per cent. of the dried weight in normal stools was 36.2. The hard, constipated stools showed no variation from this figure. In the stools not quite normal in appearance the average fat per cent. was slightly lower. In severe diarrhea the fat per cent. of dried weight was much higher, reaching an average of 40.7 per cent.

3. The soap per cent. of total fat was very high in both normal and constipated stools, averaging, respectively, 72.8 and 73.8 per cent. As the stools became less normal in appearance the soap fat diminished rapidly and averaged in the loose stools only 30.6 per cent. of the total fat, in the diarrheal stools 12.4 per cent., and in those of severe diarrhea only 8.8 per cent. of the total fat.

4. The neutral fat was less than 10 per cent. of the total fat in normal and constipated stools. It increased as the soap fat diminished and in diarrheal conditions made up about 60 per cent. of the total fat in the stool.

5. The free fatty acids constituted about 17 per cent. of the total fat of normal and of constipated stools. It was increased somewhat as the stools became less like the normal and in the diarrheal stools was over 30 per cent. of the total fat of the stool.

6. No definite relationship was shown between the daily fat intake and the per cent. of fat or the distribution of fat in the stool.

7. The average per cent. of the fat retained with normal stools was 91.3 per cent. of the intake. The retention was but little lower when the stools were somewhat harder or softer than normal, or were not homogeneous, or contained more or less mucus without being distinctly watery. As the water in the stools increased, the per cent. of retention dropped markedly, reaching in severe diarrhea 58.4 per cent. of the intake.

8. There was no striking relation between the fat intake and the per cent. of the intake retained, except when the intake was abnormally low.

CLINICAL DEPARTMENT

INFANTILE SCURVY ASSOCIATED WITH HEREDITARY SYPHILIS

REPORT ON A BREAST FED INFANT WITH MULTIPLE FRACTURES *

ROY M. GREENTHAL, M.D.
ANN ARBOR, MICH.

Owing to the prevalence of infantile scurvy and hereditary syphilis, it would seem that the association of these two diseases should not be rare. In view of the scant reference to this possibility in the available literature, it occurred to me that the report of such a case might prove of interest, especially one occurring in a breast fed infant and accompanied by multiple fractures of the long bones of the lower extremities.

REPORT OF CASE

CASE.—Penelope K., a Greek girl, aged 3 months, was admitted to the Pediatric Clinic of the University Hospital, July 1, 1918. Chief complaint, pain on moving the legs.

Family History.—Mother has had three miscarriages, one at the third and two at the seventh month, respectively.

Birth History.—Papular plantopalmar eruption persisting three weeks and then fading.

Feeding History.—Breast fed throughout, with satisfactory gain in weight and unattended by digestive disturbances.

Past Illness.—None.

Present Illness.—Ten days prior to entrance the baby became very restless and screamed with pain whenever its legs were moved or touched. Camphorated oil was applied by the mother without relief. Since the onset of the trouble the baby has not nursed well and has vomited frequently after feedings. There was no history of ecchymoses, hematuria or melena, no fever and no history of an injury.

Physical Examination.—A well developed and well nourished girl baby; lies on its back, with hips flexed and knees abducted; has characteristic snuffles; gums over the upper front teeth are red and swollen; liver palpable 3 cm. below the rib margin; spleen just palpable; upper extremities normal; lower extremities normal as to size and shape, with no visible swellings, but very sensitive to touch and movement. Painful bilateral bony swellings are palpable just above the lower tibial and femoral epiphyses and extending about 5 cm. up the shafts. There is enlargement of all the peripheral lymph nodes, but no ecchymoses or cutaneous eruptions.

Laboratory Findings.—Urine: negative for albumin, sugar, casts and blood. Blood: red blood cells, 4,200,000; white blood cells, 8,300; hemoglobin, 75 per

* From the Department of Pediatrics and Contagious Diseases, University of Michigan Hospital. I am indebted to Dr. Cowie and Dr. Van Zwaluwenberg for their kindly criticism and assistance in preparing this report.

cent. (Miescher). Von Pirquet, negative. Wassermann, 4 plus; mother's blood, 4 plus; father's blood, 4 plus. Mother's Milk: fat, 3.9 per cent.; sugar, 6.8 per cent.; protein, 2.1 per cent.

Roentgen-Ray Report.—July 3 (Dr. Van Zwaluwenberg): "Multiple fractures of both tibiae and femurs just proximal to the epiphyses of the lower ends; also a double contouring of both shafts, particularly of the femurs, representing a periosteal irritation. There is a distinct white line at the epiphyseal margin. These latter features point directly to a scorbutus, and we imagine that the fractures are a complicating phenomena."

Management and Progress.—Breast feeding every three hours was followed and orange juice, 1 ounce daily, was given. Because of the slight displacement of the fractures, no surgical treatment was instituted.

After the fourth day there was absolutely no pain on moving the legs. The baby nursed much better, and there was a slight gain in weight.

On the twelfth day the baby seemed perfectly normal except for the fractures, and the snuffles, which persisted. Neosalvarsan and mercury with chalk were given and maintained until discharge.

The roentgen report, August 13, forty-third day, was: "The main difference from the previous plates is in the calcification of the fractures, there being a large callus at each position. Also there is a disappearance of the white line at the epiphyses."

The patient was discharged on the sixty-sixth day (September 4) much improved.

Explanation of the Bone Changes.—The roentgenograms of the bones of the lower extremities reveal three interesting findings: (1) a "white line" at the epiphyseal margins; (2) multiple fractures of both femurs and tibia situated just above the epiphyses; (3) periosteal thickening of the shafts of the bones, especially of the femurs. Several possibilities are to be considered in the diagnosis, namely, syphilis, rickets, osteogenesis imperfecta, scurvy.

Syphilis.—The family history, physical findings—snuffles, palpable liver and spleen, adenitis, positive Wassermann reaction on both child and parents—prove conclusively that syphilis is present. The bone changes seen in syphilitic infants, however, are different from those found here. In syphilis the usual finding is an epiphysitis, which is not present in this case. Fractures do not occur in syphilitic bones, as a rule, except when there are gummas present. As gummas never occur in the bones of hereditary syphilitics, fractures are practically never found. Epiphyseal separation is most often observed. The periostitis of syphilis is usually of the girdle type, encircling the whole shaft of the bone, and usually occurs in several bones. In this case there is no evidence of that type of periostitis.

Rickets.—A "white line" at the epiphysis may suggest rickets. This line is not the smooth, broad line seen in scurvy, but a jagged, irregular line. The epiphysis appeared frayed out. The "white line" does not occur until after the process has healed, and other characteristic bone changes, which are not present in this case, are usually seen.

Osteogenesis Imperfecta.—This condition is suggested because of the multiple fractures. There are no other signs of this rare disease present, however, such as the thinning of the cortex and diminution of calcium in the medulla of the bone.

Scurvy.—This condition will explain all of the bone changes. The smooth "white line" at the epiphysis is regarded by all authorities as diagnostic of scurvy. The "white line" does not occur in hereditary syphilis. Multiple fractures are not a common complication of scurvy, but they do occur. In scurvy the bones are somewhat more fragile

Figure 1 Figure 2

Fig. 1.—Showing white line at epiphyseal margin of tibia and fracture of tibia and fibula with little displacement.

Fig. 2.—Showing white line at the epiphyseal margin and the fracture above the epiphysis on the opposite extremity, with little displacement.

than normal, and fractures might easily occur. The periostitis, characteristic of scurvy, is a localized one, and is not of the girdle type. This is the condition found in this case.

A second roentgenogram, taken six weeks after the first, shows disappearance of the "white line" and good union of the fractures. As the baby had not received its full course of antisyphilitic treatment, but had been on orange juice all this time, it would seem as if antiscorbutic treatment was responsible for the change at the epiphyses.

Pain on Moving the Legs.—The pain on moving the legs was regarded as partly due to scurvy and partly to the fractures. A few days after receiving orange juice there was absolutely no pain on motion, and the baby moved her limbs spontaneously. As the fractures were of a type in which there was very little displacement, they prob-

ably would not have caused such excruciating pain as was noticed on admission. Coincidently with the disappearance of the pain, there was noticed a clearing up of the gums.

CONCLUSION

It would seem that we are justified in concluding that both syphilis and scurvy are present in this case: syphilis on the grounds of the history, physical findings and Wassermann reactions; scurvy on the grounds of characteristic bone pathology, changes in the gums and striking response to the administration of orange juice.

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